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VII.

ON THE PERIODIC ERRORS OF THE RIGHT ASCENSIONS
OBSERVED BETWEEN 1858 AND 1871.

BY WILLIAM A. ROGERS.

Read, April 14, 1874.

PART I.

It is the purpose of this investigation to determine for the Right Ascensions observed between 1858 and 1871, the periodic errors of single period, as expressed by an equation of the form:—

$$m \sin \alpha + n \cos \alpha = r.$$

The periodic errors of double period, as expressed by an equation of the form:—

$$m' \sin 2\alpha + n' \cos 2\alpha = r'.$$

And the periodic errors depending on the Declination, as expressed by an equation of the form:—

$$a \sin \delta + b \cos \delta = r''.$$

The complete solution of the problem requires:—

(a) That the assumed Right Ascensions with which any system of observations is compared shall be free both from periodic and from accidental errors.

(b) That the system of observations whose periodic errors are to be determined shall be free from accidental errors.

From the nature of the case, neither of these conditions can be exactly fulfilled; but an approximate solution may be had by either of the following methods:—

I. A standard catalogue may be selected, in which especial care has been taken to eliminate periodic errors of single period, by making the clock errors employed in the reductions, depend upon observations

separated by an interval of 12 hours. By employing a large number of stars, accidental errors may be nearly eliminated from the mean of any group. With this standard catalogue any other catalogue may be compared, and from the mean of the residuals about each hour of Right Ascension there may be formed 24 equations of the form:—

$$\begin{aligned} m \sin 1^h + n \cos 1^h &= r, \\ m \sin 2^h + n \cos 2^h &= r_1, \text{ \&c.,} \end{aligned}$$

from which m and n can be obtained by the process of least-squares. Either the Pulkowa catalogue for 1845, the Aboë catalogue for 1828, or the Dorpat catalogue for 1830, might be selected for this purpose with great advantage, were it not for the occasional uncertainty in the value of the proper motions with which the Right Ascensions are brought forward to the present time. But it will be seen from this investigation, that no series of observations made since 1858 is wholly free from the errors in question.

In the earlier investigations on this subject, especially in the one given by Professor Safford (*Monthly Notices of the Royal Astronomical Society*, Vol. XXI., No. 9), who seems to have been the first to suggest the present form of discussion, the standard or Greenwich 12 Year Catalogue, is assumed to be free from periodic errors. A similar assumption with respect to the Washington Observations seems also to have been partially made by Professor Newcomb, in deriving the periodic equation for Dr. Gould's catalogue of fundamental stars from the Washington Observations from 1862 to 1867. (Washington Observations for 1867.) While the error arising from this source is considerable in the latter case, it has nevertheless a sensible magnitude.

II. Instead of depending upon a large number of stars to secure freedom from accidental errors, we may employ only the Maskelyne fundamental stars of the first and second magnitude, relying for our purpose, upon their more accurately determined places. If the assumed Right Ascensions of these stars have been determined by a process from which differential observations have been excluded, and in which great care has been taken to employ only data from which periodic errors have been eliminated by the method of observation, the whole system of Right Ascensions may be regarded as homogeneous. Even if this condition is not exactly fulfilled, if the periodic coefficients for different catalogues have opposite signs, the resulting system may safely be assumed to be nearly homogeneous, and nearly free from periodic errors of all kinds.

If, from the standard catalogue thus formed, accidental errors can be excluded, comparing with any other catalogue, we shall have directly for each star periodic equations of the form, —

$$\begin{aligned} m \sin a + n \cos a &= r, \\ m' \sin 2a + n' \cos 2a &= r', \\ a \sin \delta + b \cos \delta &= r''; \end{aligned}$$

from which, the periodic coefficients can be successively found by least-squares; and, with these coefficients thus obtained, a system of corrections may be computed for each hour of Right Ascension.

In the absence of any system of observations since 1858, made with especial reference to freedom from periodic errors, this method will be employed in this investigation. The standard catalogue selected, is given by the following title:—

“On the Right Ascensions of the Equatorial Fundamental Stars, and the Corrections necessary to reduce the Right Ascensions of Different Catalogues to a Mean Homogeneous System. By Simon Newcomb, Professor of Mathematics, United States Navy.”

This catalogue of 32 fundamental stars proves to be far more accurate than any hitherto constructed. Indeed, it seems almost superfluous to attempt any corrections for accidental errors. I shall, however, venture a thorough comparison with only modern observations, on the supposition that they are somewhat more accurately made than earlier ones, especially those made since the introduction of the chronograph.

Since the assumed system of Right Ascensions is supposed to be entirely homogeneous, the corrections obtained will be independent of the time of observation; and, when once obtained, may be applied to the whole system. I conceive it to be possible, in this way (assuming, of course, that the annual variations are correctly known), to correct the accidental errors of any part of the system, by observations made at the point of time and under the conditions most favorable to accuracy.

A preliminary and tentative discussion, by the method above indicated, gave the following periodic equations, viz.:—

GREENWICH. — Observations from 1860 to 1870,	$r = -.010 \sin a + .007 \cos a$
EDINBURGH. — Observations from 1860 to 1869,	$r = -.009 \sin a + .006 \cos a$
OXFORD. — Observations from 1860 to 1870,	$r = -.012 \sin a + .019 \cos a$
WASHINGTON. — Observations from 1860 to 1870,	$r = -.009 \sin a + .007 \cos a$
HARVARD COLLEGE. — Observations in 1871,	$r = -.010 \sin a + .003 \cos a$

After reducing the equinox of the different catalogues to that of the standard catalogue, and subtracting from the residuals given by direct

comparison with observation, the values of r derived from the periodic equations of single period, the following corrections to Newcomb's catalogue were obtained, viz.:—

CORR.	CORR.	CORR.	CORR.	CORR.
+ .00 ^s	+ .01 ^s	— .01 ^s	+ .02 ^s	— .02 ^s
α Andromedæ,	β Orionis,	γ Pegasi,	α Canis Majoris,	α Aurigæ.
α Arietis,	β Tauri,	α Scorpii,	α Piscis Aust.	
α Ceti,	α Orionis,	α Aquilæ,		
α Tauri,	α Canis Minoris,	α Cygni.		
β Geminorum,	α Bootis,			
α Hydræ,	α^2 Libræ,			
α Leonis,	α Serpentis,			
β Leonis,	α Ophiuchi,			
α Virginis,	γ Aquilæ,			
α Coronæ,	β Aquilæ,			
α Herculis,	α^2 Capricorni,			
α Lyræ,	α Aquarii.			
α Pegasi.				

The slight preponderance of positive corrections is due, partly to the fact that only the nearest hundredth of a second was taken, and partly to the fact that no account was taken of corrections depending on the Declination. It will be found that there is a general tendency to positive corrections, when the corrections for errors of single period only, are applied. The introduction of corrections for errors of double period has a slight tendency to restore the equilibrium. It is only when the corrections depending on the Declination are applied that the equinox is restored to its original assumed position.

In this discussion of late observations, the following data will be employed:—

- (1) GREENWICH. — The Greenwich Observations from 1858 to 1870, inclusive.
- (2) WASHINGTON, I. — The Washington Observations from 1862 to 1870. The Right Ascensions given are found by applying the corrections to the American Ephemeris, given in the annual volumes. The epoch for the years 1862–3–4 is 1860.0. For the remaining years it is 1870.0.
- (3) WASHINGTON, II. — The Washington Observations from 1858 to 1861. These observations, mostly made by Professor Yarnall, are purely differential, and depend on the positions given in the Nautical Almanac for 1860. As they show an excellent agreement *inter se*, their discussion will show how far the periodic errors of the standard catalogue are transferred to the observed.
- (4) PARIS. — The Paris Observations from 1858 to 1866.
- (5) MELBOURNE. — The Melbourne Observations from 1858 to 1868. The places for 1860 depend on the observations of 1858–59–60.
- (6) BRUSSELS. — The Brussels Observations from 1858 to 1866.

- (7) OXFORD. — The Oxford Observations from 1858 to 1870.
 (8) EDINBURGH. — The Edinburgh Observations from 1860 to 1869.
 (9) HARVARD COLLEGE. — The Harvard College Observations for 1871. The places are taken from *Ast. Nach.*, Nos. 1909 and 1947, except those for α Bootis, α Scorpii, α Ophiuchi, and α Lyræ, which depend on the observations there given, and upon additional observations in 1872. The corrections are as follows:—

α Bootis	= +.02 ^s
α Scorpii	= +.06
α Ophiuchi	= —.01
α Lyræ	= +.08

On the following pages are arranged:—

First, The assumed Right Ascension of each star; and, under the various authorities, the observed places in hundredths of seconds.

Second, The residuals formed by subtracting the observed from the assumed Right Ascensions. Instead of attempting to apply weights proportional to the number of observations, discordant results which depend on 3 observations or less are included in brackets, to indicate their rejection. Beyond this, all observations are assumed to have equal weight.

α ANDROMEDÆ.				Paris.	Green- wich.	Mel- bourne.	Brussels.	Oxford.	Edin- burgh.	Washing- ton, I.	Washing- ton, II.	Harvard College.
	<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>
1858	0	1	3.28	.24	.28		.17					
1859		1	6.37	.29	.37		.28					.36
1860		1	9.45	.37	.47	.40	.31	.38	.40			.42
1861		1	12.54	.49	.53		.44	.46	.47			.34
1862		1	15.63	.58	.57		.54	.60	.59	.42		.32
1863		1	18.71	.63	.67	.61	.63	.54	.70	.42		
1864		1	21.80	.74	.80	.71	.73	.71	.78	.45		
1865		1	24.89	.85	.84	.84	.86	.82	.88	.27		
1866		1	27.97	.91	.95	.90	.96	.81	.94	.30		
1867		1	31.06		.05	.95		.01	.02	.30		
1868		1	34.15		.14	.10		.24	.11	.29		
1869		1	37.24		.19			.18	.19	.29		
1870		1	40.32		.28			.28		.32		
1871		1	43.41									.86

γ PEGASI.												
1858	0	5	55.65	.60	.65		.60					.72
1859		5	58.73	.70	.72		.67					.77
1860		6	1.81	.75	.77	.75	.78	.77	.76			.76
1861		6	4.89	.83	.87		.82	.90	.90			.74
1862		6	7.97	.89	.90			.85	.94	.78		
1863		6	11.05	.00	.97	.95	.02	.88	.02	.77		
1864		6	14.13	.07	.10	.08	.07	.00	.09	.78		
1865		6	17.21	.16	.17	.14	.10	.14	.21	.59		
1866		6	20.29	.23	.27	.22		.25	.27	.64		
1867		6	23.38		.34	.32		.32	.38	.61		
1868		6	26.46		.42	.40		.38	.46	.64		
1869		6	29.54		.53			.50	.52	.60		
1870		6	32.62		.55			.68		.69		
1871		6	35.70									.69

α ARIETIS.												
1858	1	59	10.57	.50	.57		.49					.25
1859		59	13.94	.89	.92		.84					.24
1860		59	17.30	.27	.28	.25	.25	.25	.29			.24
1861		59	20.67	.63	.62		.57	.64	.60			.24
1862		59	24.04	.01	.02		.01	.96	.01	.29		
1863		59	27.40	.34	.42	.28	.30	.37	.38	.27		
1864		59	30.77	.70	.73	.72	.73	.68	.77	.29		
1865		59	34.13	.09	.09	.10	.05	.12	.10	.96		
1866		59	37.50	.47	.47	.42	.40	.46	.46	.95		
1867		59	40.86		.82	.76		.88	.81	.95		
1868		59	44.23		.18	.17		.25	.22	.95		
1869		59	47.60		.53			.69	.54	.95		
1870		59	50.97		.92			.99		.97		
1871		59	54.33									.28

TABULAR AND OBSERVED RIGHT ASCENSIONS (*continued*).

α CETI.			Paris.	Green- wich.	Mel- bourne.	Brussels.	Oxford.	Edin- burgh.	Washing- ton, I.	Washing- ton, II.	Harvard College.
	<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>
1858	2	54	51.62	.58	.63	.48				.81	
1859		54	54.74	.72	.73	.68				.82	
1860		54	57.87	.82	.81	.90	.89	.87		.81	
1861		55	1.00	.97	.01	.95	.05	.92		.79	
1862		55	4.12	.04	.08	.00	.16	.05	.87		
1863		55	7.25	.19	.22	.20	.22	.19	.21	.89	
1864		55	10.38	.88	.35	.35	.30	.29	.86		
1865		55	13.51	.49	.49	.43	.50	.46	.16		
1866		55	16.64	.62	.62	.60	.60	.55	.16		
1867		55	19.77		.73	.73	.75	.70	.15		
1868		55	22.89	.88	.85		.83	.82	.18		
1869		55	26.02	.96			.93	.95	.18		
1870		55	29.15		.10		.06		.19		
1871		55	32.28								25
α TAURI.											
1858	4	27	46.57	.57	.54	.54				.40	
1859		27	50.00	.99	.00	.96				.42	
1860		27	53.44	.43	.42	.39	.43	.42		.42	
1861		27	56.87	.84	.88	.82	.82	.84		.40	
1862		28	0.30	.28	.27	.30	.20	.28	.45		
1863		28	3.74	.72	.73	.71	.72	.73	.46		
1864		28	7.17	.17	.16	.13	.22	.13	.44		
1865		28	10.61	.58	.61	.60	.64	.62	.78		
1866		28	14.04	.00	.02	.99	.03	.06	.00	.76	
1867		28	17.48		.48	.43	.40	.43	.77		
1868		28	20.91		.90	.86	.97	.90	.76		
1869		28	24.35		.31		.32	.32	.79		
1870		28	27.79		.76		.73		.78		
1871		28	31.22								.19
α AURIGÆ.											
1858	5	6	12.26	.27	.25	.20				.07	
1859		6	16.68	.70	.72	.60				.09	
1860		6	21.10	.11	.14	.96	.06			.06	
1861		6	25.52	.50	.54		.44			.03	
1862		6	29.94	.87	.95	.93	.65		.02		
1863		6	34.36	.39	.32	.31			.12		
1864		6	38.78	.85	.82	.74	.99				
1865		6	43.20	.18	.14	.22	.71		.15		
1866		6	47.62	.49	.60	.76	.53		.29		
1867		6	52.04		.07	.98			.21		
1868		6	56.46		.42	.51			.36		
1869		7	0.88		.84		.91		.23		
1870		7	5.31		.20		.25		.39		
1871		7	9.74								.67

TABULAR AND OBSERVED RIGHT ASCENSIONS (*continued*)

[illegible]

TABULAR AND OBSERVED RIGHT ASCENSIONS (*continued*).

α VIRGINIS.			Paris.	Green- wich.	Mel- bourne.	Brussels.	Oxford.	Edin- burgh.	Washing- ton, I.	Washing- ton, II.	Harvard College.
	<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>
1858	18	17	43.00	.99	.98		.97				
1859		17	46.15	.11	.10		.08			.32	
1860		17	49.30	.27	.26	.26	.22	.29		.24	
1861		17	52.45	.45	.43		.40	.48		.26	
1862		17	55.60	.59	.59		.56	.74	.31	.29	
1863		17	58.76	.76	.73	.73	.66	.76	.31		
1864		18	1.91	.92	.87	.87	.84	.90	.32		
1865		18	5.06	.07	.04	.02	.08	.82	.32	.84	
1866		18	8.21	.12	.18	.20	.25	.11	.81		
1867		18	11.36		.33	.34		.28	.82		
1868		18	14.51		.46	.46		.48	.81		
1869		18	17.66		.64		.59		.81		
1870		18	20.81		.71		.85		.79		.94
1871		18	23.97								
α BOOTIS.											
1858	14	9	11.16	.18	.14		.10			.56	
1859		9	13.89	.86	.88		.82			.60	
1860		9	16.63	.59	.61	.57	.57	.55		.55	
1861		9	19.36	.30	.33		.32	.35	.63	.52	
1862		9	22.09	.98	.06		.07	.04	.04	.62	
1863		9	24.83	.80	.79	.78	.72	.85	.82	.61	
1864		9	27.56	.53	.56	.46		.65	.54	.64	
1865		9	30.30	.23	.26	.20	.26	.33	.33	.95	
1866		9	33.03	.97	.99	.00	.99	.99	.00	.94	
1867		9	35.77		.74	.72		.76	.75	.95	
1868		9	38.50		.45	.43		.53	.50	.94	
1869		9	41.24		.19			.23	.22	.98	
1870		9	43.97		.89		.92			.95	
1871		9	46.70								.68
α^2 LIBRÆ.											
1858	14	43	1.74	.74	.69		.63				
1859		43	5.05	.06	.98		.04			.28	
1860		43	8.35	.31	.29	.28	.26	.32		.29	
1861		43	11.66	.64	.62		.59	.61		.29	
1862		43	14.96	.94	.93		.83	.94	.32		
1863		43	18.27	.25	.23	.25	.15	.23	.32		
1864		43	21.57	.55	.53	.53	.53	.51	.30		
1865		43	24.88	.84	.86	.86	.78	.90	.39		
1866		43	28.19	.13	.18	.16	.19	.17	.41		
1867		43	31.49		.50	.45		.48	.41		
1868		43	34.80		.74	.74		.82	.40		
1869		43	38.10		.10			.11	.44		
1870		43	41.41		.40		.41		.40		
1871		43	44.72								.74

α CORONÆ.			Parls.	Green- wich.	Mel- bourne.	Brussels.	Oxford.	Edin- burgh.	Washing- ton, I.	Washing- ton, II.	Harvard College.
	<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>
1858	15	28	40.61	.58	.60	.55				.60	
1859		28	43.15	.09	.13	.05				.58	
1860		28	45.69	.62	.69	.64	.67	.70		.57	
1861		28	48.23	.14	.21	.20	.21	.20			
1862		28	50.76	.68	.76	.72	.72	.77	.67		
1863		28	53.30	.24	.28	.18	.31	.31	.65		
1864		28	55.84	.76	.81	.78	.83	.85	.70		
1865		28	58.38	.33	.35	.31	.33	.41	.05		
1866		29	0.92	.88	.89	.83	.87	.91	.93	.03	
1867		29	3.46		.44		.38	.46	.06		
1868		29	6.00		.96	.92	.10	.99	.03		
1869		29	8.53		.50		.52	.54	.07		
1870		29	11.07		.01		.07		.06		
1871		29	13.61								.57

α SERPENTIS.										
	<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>
1858	15	37	16.57	.52	.54	.53				
1859		37	19.52	.48	.49	.42				.39
1860		37	22.47	.41	.44	.42	.43	.44		.39
1861		37	25.42	.36	.40	.38	.37			.38
1862		37	28.37	.35	.31	.29	.39	.34	.44	
1863		37	31.32	.28	.26	.28	.31	.28	.44	
1864		37	34.27	.25	.23	.21	.22	.19	.51	
1865		37	37.22	.17	.20	.15	.10	.21	.17	.92
1866		37	40.17	.15	.12	.08	.13	.13	.96	
1867		37	43.12		.12	.06	.06	.07	.99	
1868		37	46.08		.04	.99	.99	.02	.97	
1869		37	49.03		.95		.03	.97	.99	
1870		37	51.98		.91		.93		.96	
1871		37	54.93							.91

α SCORPII.										
	<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>
1858	16	20	42.38	.38	.35	.32				.74
1859		20	46.05	.07	.98	.95				.67
1860		20	49.72	.75	.63	.62	.70			.67
1861		20	53.38	.40	.34	.28	.37			.71
1862		20	57.05	.08	.00	.97	.98		.71	
1863		21	0.71	.71	.73	.68	.65	.65	.72	
1864		21	4.38	.39		.32	.29	.31	.72	
1865		21	8.05	.06	.01	.97	.01	.07	.36	
1866		21	11.71	.68	.72	.68	.70	.72	.40	
1867		21	15.38		.38	.30		.39	.43	
1868		21	19.05		.01	.97			.37	
1869		21	22.71		.68		.74		.41	
1870		21	26.38		.38		.32		.32	
1871		21	30.05							.04

TABULAR AND OBSERVED RIGHT ASCENSIONS (*continued*).

α HERCULIS.			Paris.	Green- wich.	Mel- bourne.	Brussels.	Oxford.	Edin- burgh.	Washing- ton, I.	Washing- ton, II.	Harvard College.
	<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>
1858	17	8	10.45	.40	.40					.84	
1859		8	13.18	.14	.25	.04				.81	
1860		8	15.91	.85	.89	.85	.79	.84		.82	
1861		8	18.65	.61	.58	.48	.47	.63		.82	
1862		8	21.38	.31	.42	.28	.29	.40	.90		
1863		8	24.11	.04	.02	.93	.05	.06	.90		
1864		8	26.84	.78	.86	.62	.81	.85	.88		
1865		8	29.58	.54	.56	.47	.55	.54	.22		
1866		8	32.31	.27	.30	.22	.18	.28	.23		
1867		8	35.04		.03	.93	.96	.05	.23		
1868		8	37.78		.74	.70	.58	.76	.24		
1869		8	40.51		.49		.51	.47	.25		
1870		8	43.24		.22		.18		.20		
1871		8	45.97								.94

α OPHIUCHI.										
	<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>
1858	17	28	20.67	.61	.64	.55				.18
1859		28	23.46	.41	.43	.37				.14
1860		28	26.24	.20	.22	.15	.13	.23		.13
1861		28	29.02	.97	.97		.92	.94		.14
1862		28	31.80	.71	.77	.71	.76	.77	.21	
1863		28	34.58	.53	.59	.51	.49	.54	.21	
1864		28	37.37	.33	.35	.23	.23	.35	.31	.18
1865		28	40.15	.08	.13	.05	.09	.14	.11	.02
1866		28	42.93	.86	.90	.84	.87	.84	.02	
1867		28	45.71		.69	.60	.69	.65	.06	
1868		28	48.49		.45	.39	.48	.47	.04	
1869		28	51.28		.24		.22	.18	.02	
1870		28	54.06		.02		.07		.03	
1871		28	56.84							.82

α LYRÆ.										
	<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>
1858	18	32	7.87	.80	.90					
1859		32	9.90	.82	.84	.87				.79
1860		32	11.93	.85	.86	.85	.84	.89	.91	.78
1861		32	13.96	.90	.93		.93	.88	.87	.76
1862		32	15.99	.87	.95		.88	.92		.90
1863		32	18.02	.94	.00	.88	.98	.91	.00	.89
1864		32	20.06	.96	.03	.88	.91	.11	.02	.91
1865		32	22.09	.99	.05	.92	.99	.03	.02	.20
1866		32	24.12	.00	.09	.02	.02	.10	.06	.22
1867		32	26.15		.12	.05		.06	.11	.23
1868		32	28.18		.14	.09		.22	.14	.20
1869		32	30.21		.17			.14	.18	.23
1870		32	32.24		.16		.16			.21
1871		32	34.27							.24

TABULAR AND OBSERVED RIGHT ASCENSIONS (*continued*).

γ AQUILÆ.			Paris.	Green- wich.	Mel- bourne.	Brussels.	Oxford.	Edin- burgh.	Washing- ton, I.	Washing- ton, II.	Harvard College.
	<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>
1858	19	39	30.54	.47	.53	.42				.15	
1859		39	33.40	.29	.34	.30				.15	
1860		39	36.25	.20	.22	.14	.13	.15		.14	
1861		39	39.10	.03	.07	.00	.97	.01		.13	
1862		39	41.95	.91	.89	.76	.90	.87	.21		
1863		39	44.81	.73	.76	.69	.72	.74	.75	.20	
1864		39	47.66	.59	.59	.56	.57	.58	.23		
1865		39	50.51	.44	.44	.40	.42	.48	.73		
1866		39	53.36	.32	.32	.24	.34	.31	.76		
1867		39	56.21		.16	.14	.17	.15	.73		
1868		39	59.07		.01	.92	.97	.03	.74		
1869		40	1.92		.88		.89	.82	.83		
1870		40	4.77		.69		.74		.76		
1871		40	7.63								.61
α AQUILÆ.											
1858	19	43	51.28	.24	.26	.22				.06	
1859		43	54.21	.16	.18	.15				.06	
1860		43	57.14	.07	.15	.06	.08	.03		.05	
1861		44	0.07	.01	.04	.99	.01	.00		.05	
1862		44	3.00	.92	.95	.91	.91	.91	.12		
1863		44	5.92	.86	.86	.84	.83	.88	.12		
1864		44	8.85	.80	.82	.75	.78	.79	.10		
1865		44	11.78	.75	.76	.66	.78	.74	.38		
1866		44	14.71	.65	.73	.66	.70	.68	.44		
1867		44	17.64		.60	.55	.73	.58	.42		
1868		44	20.56		.53	.48	.52	.53	.41		
1869		44	23.49		.48		.46	.44	.46		
1870		44	26.42		.38		.38		.40		
1871		44	29.35								.31
β AQUILÆ.											
1858	19	48	20.30	.23	.25	.18				.13	
1859		48	23.25	.16	.24	.13				.09	
1860		48	26.19	.09	.11	.09	.19	.09		.08	
1861		48	29.14	.08	.08	.02	.16	.10		.08	
1862		48	32.09	.06	.06	.99	.12	.03	.14		
1863		48	35.04	.96	.01	.91	.88	.94	.14		
1864		48	37.98	.92	.92	.89	.88	.96	.19		
1865		48	40.93	.86	.87	.85	.87	.87	.62		
1866		48	43.88	.79	.82	.75	.80	.80	.65		
1867		48	46.83		.79	.73	.66	.83	.63		
1868		48	49.77		.71	.68	.70	.73	.64		
1869		48	52.72		.68		.66	.68	.75		
1870		48	55.67		.60		.65		.67		
1871		48	58.62								.58

TABULAR AND OBSERVED RIGHT ASCENSIONS (*continued*).

α^2 CAPRICORNI.			Paris.	Green- wich.	Mel- bourne.	Brussels.	Oxford.	Edin- burgh.	Washing- ton, I.	Washing- ton, II.	Harvard College.
	<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>
1858	20	10	10.42	.36	.34	.38				.96	
1859		10	13.75	.74	.65	.62				.96	
1860		10	17.09	.11	.04	.92	.08			.00	
1861		10	20.42	.40	.37	.29	.51			.98	
1862		10	23.76	.67	.68	.59	.72		.01		
1863		10	27.09	.00	.05	.96	.06		.04		
1864		10	30.43	.39	.40	.38	.26		.00		
1865		10	33.76	.70	.70	.72	.65		.38		
1866		10	37.09	.04	.08	.96	.04		.41		
1867		10	40.43		.40	.31	.35		.46		
1868		10	43.76		.72	.70	.70		.41		
1869		10	47.10		.06		.99				
1870		10	50.43		.40		.38		.41		
1871		10	53.77								
α CYGNI.											
1858	20	36	35.52	.42	.53	.48				.55	
1859		36	37.56	.46	.51	.55				.58	
1860		36	39.61	.59	.51	.54	.47			.56	
1861		36	41.65	.58	.70	.41	.71			.45	
1862		36	43.70	.59	.71	.58	.45		.59		
1863		36	45.74	.60	.71	.68	.76	.72	.59		
1864		36	47.78	.66	.85	.70	.73	.69	.58		
1865		36	49.83	.69	.81	.71	.75		.00		
1866		36	51.87	.76	.83	.76	.76		.98		
1867		36	53.91		.84	.91	.86		.08		
1868		36	55.96		.94		.93		.99		
1869		36	58.00		.07		.89	.10	.95		
1870		37	0.05		.98		.94		.12		
1871		37	2.09								.05
α AQUARI.											
1858	21	58	29.39	.32	.33	.30				.47	
1859		58	32.47	.41	.39	.38				.47	
1860		58	35.56	.50	.50	.47	.49	.52		.45	
1861		58	38.64	.56	.60	.52	.64	.58		.46	
1862		58	41.73	.68	.69	.62	.66	.67	.50		
1863		58	44.81	.73	.72	.75	.73	.72	.74	.50	
1864		58	47.89	.83	.82	.82	.85	.79	.49		
1865		58	50.98	.89	.90	.91	.86	.99	.87	.37	
1866		58	54.06	.01	.02	.02		.95	.39		
1867		58	57.15		.07	.07	.09	.07	.39		
1868		59	0.23		.17	.15	.14	.09	.40		
1869		59	3.31		.26		.26	.20	.40		
1870		59	6.40		.36		.34		.41		
1871		59	9.48								.48

TABULAR AND OBSERVED RIGHT ASCENSIONS (*continued*).

<i>α</i> PISCIS AUSTRALIS.			Parls.	Green- wich.	Mel- bourne.	Brussels.	Oxford.	Edin- burgh.	Washing- ton, I.	Washing- ton, II.	Harvard College.
	<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>
1858	22	49	47.80	.73	.69		.81			.35	
1859		49	51.13	.11	.05		.93			.35	
1860		49	54.46	.33	.37	.40	.37	.40		.37	
1861		49	57.80	.76	.72		.58	.70		.43	
1862		50	1.13	.19	.04		.04	.10	.41		
1863		50	4.46		.37	.39		.19	.40		
1864		50	7.79	.70	.78	.68	.64	.71	.43		
1865		50	11.12	.06	.07	.02	.09	.07	.78		
1866		50	14.45	.37	.35	.39	.32		.75		
1867		50	17.78		.71	.73		.82	.82		
1868		50	21.11		.07	.01		.10	.79		
1869		50	24.44		.37			.31			
1870		50	27.77				.69		.83		
1871		50	31.09								.12
<i>α</i> PEGASI.											
1858	22	57	41.40	.36	.38		.27			.32	
1859		57	44.39	.36	.32		.32			.33	
1860		57	47.37	.29	.33	.29	.30	.33	.32	.28	
1861		57	50.35	.29	.34		.28	.31		.29	
1862		57	53.34	.25	.35		.22	.26	.30	.35	
1863		57	56.32	.23	.23	.24	.24	.20	.28	.34	
1864		57	59.30	.22	.26	.22	.20	.27	.37		
1865		58	2.29	.22	.24	.17	.21	.23	.25	.18	
1866		58	5.27	.16	.23	.20	.21	.34	.23	.21	
1867		58	8.26		.25	.17		.25	.19	.19	
1868		58	11.24		.22	.14		.10	.20	.20	
1869		58	14.22		.14			.18	.19	.23	
1870		58	17.21		.16		.17		.22		
1871		58	20.19								.18

COMPARISON OF OBSERVED WITH TABULAR PLACES.

α ANDRO-MEDÆ.	Paris.	Greenwich.	Melbourne.	Brussels.	Oxford.	Edinburgh.	Washington, I.	Washington, II.	Harvard College.
1858	s. +.04	s. +.00	s. +	s. +.11	s. +	s. +	s. +	s. +.09	s. +
1859	+.08	+.00		+.09				+.03	
1860	+.08	-.02	+.05	+.14	+.07	+.05		+.11	
1861	+.05	+.01		+.10	+.08	+.07		+.13	
1862	+.05	+.06		+.09	+.03	+.04	+.03		
1863	+.08	+.04	+.10	+.08	+.17	+.01	+.03		
1864	+.06	+.00	+.09	+.07	+.09	+.02	+.00		
1865	+.04	+.05	+.05	+.03	+.07	+.01	+.05		
1866	+.06	+.02	+.07	+.01	+.16	+.03	+.02		
1867		+.01	+.11		+.05	+.04	+.02		
1868		+.01	+.05		-.09	+.04	+.03		
1869		+.05			+.06	+.05	+.03		
1870		+.04			+.04		+.00		
1871									+.05
Means	+.060	+.021	+.074	+.080	+.066	+.036	+.023	+.090	+.050

γ PEGASI.									
1858	+.05	+.00		+.05				+.09	
1859	+.03	+.01		+.06				+.04	
1860	+.06	+.04	+.06	+.03	+.04	+.05		+.05	
1861	+.06	+.02		+.07	-.01	-.01		+.07	
1862	+.08	+.07			+.12	+.03	+.03		
1863	+.05	+.08	+.10	+.03	+.17	+.03	+.04		
1864	+.06	+.03	+.05	+.06	+.13	+.04	+.03		
1865	+.05	+.04	+.07	+.11	+.07	+.00	+.03		
1866	+.06	+.02	+.07		+.04	+.02	-.02		
1867		+.04	+.06		+.06	+.00	+.01		
1868		+.04	+.06		+.08	+.00	-.02		
1869		+.01			+.04	+.02	+.02		
1870		+.07			-.06		-(.07)		
1871									+.01
Means	+.056	+.036	+.067	+.059	+.062	+.018	+.015	+.062	+.010

α ARIETIS.									
1858	+.07	+.00		+.08				+.05	
1859	+.05	+.02		+.10				+.06	
1860	+.03	+.02	+.05	+.05	+.05	+.01		+.06	
1861	+.04	+.05		+.10	+.03	+.07		+.06	
1862	+.03	+.02		+.03	+.08	+.03	+.01		
1863	+.06	-.02	+.12	+.10	+.03	+.02	+.03		
1864	+.07	+.04	+.05	+.04	+.09	+.00	+.01		
1865	+.04	+.04	+.03	+.08	+.01	+.03	+.01		
1866	+.03	+.03	+.08	+.10	+.04	+.04	+.02		
1867		+.04	+.10		-.02	+.05	+.02		
1868		+.05	+.06		-.02	+.01	+.02		
1869		+.07			-.09	+.06	+.02		
1870		+.05			-.02		+.00		
1871									+.05
Means	+.047	+.032	+.070	+.076	+.016	+.032	+.016	+.058	+.050

COMPARISON OF OBSERVED WITH TABULAR PLACES (*continued*).

α Ceti.	Paris.	Greenwich.	Melbourne.	Brussels.	Oxford.	Edinburgh.	Washington, I.	Washington, II.	Harvard College.
	s.	s.	s.	s.	s.	s.	s.	s.	s.
1858	+04	—01		+14				+06	
1859	+02	+01		+06				+05	
1860	+05	+06	+06	—03	—02	+00		+06	
1861	+03	—01		+05	—05	+08		+08	
1862	+08	+04		+12	—04	+07	+00		
1863	+06	+03	+05	+03	+06	+04	—02		
1864	+00	+03	+03	+01	+08	+09	+01		
1865	+02	+02	+08	+03	+01	+05	—01		
1866	+02	+02	+04	+01	+04	+09	—01		
1867		+04	+04		+02	+07	—00		
1868		+01	+04		+06	+07	—03		
1869		+06			+09	+07	—03		
1870		+05			+09		—04		
1871									+03
Means	+036	+027	+049	+047	+081	+063	—014	+062	+030
α Tauri.									
1858	+00	+03		+03				+04	
1859	+01	+00		+04				+02	
1860	+01	+02	+04	+05	+01	+02		+02	
1861	+03	—01		+05	+05	+03		+04	
1862	+02	+03		+00	+10	+02	—01		
1863	+02	+01	+03	+04	+02	+01	—02		
1864	+00	+01	+04	—05	+04	+00	+00		
1865	+03	+00	+01	+03	—03	—01	+01		
1866	+04	+02	+05	+01	—02	+04	+03		
1867		+00	+05		+08	+05	+02		
1868		+01	+05		—06	+01	+03		
1869		+04			+03	+03	+00		
1870		+03			+06		+01		
1871									+03
Means	+018	+015	+039	+031	+017	+024	+008	+030	+030
α Aurigæ.									
1858	—01	+01		+06				+03	
1859	—02	—04		+08				+01	
1860	—01	—04	—02	+(.14)	+04			+04	
1861	+02	—0			+08			+07	
1862	+07	—01		+01	+(.29)		+08		
1863	—03	+04		+05			—02		
1864	—07	—04	+04	+03	—(.21)				
1865	+02	+06	—02		—(.51)		+(.16)		
1866	+13	+02	—(.14)	+(.09)			+02		
1867		—03	+06				+10		
1868		+04	—05		—03		—05		
1869		+04			+06		+08		
1870		+11					—08		
1871									+07
Means	+011	+011	+002	+046	+038		+019	+038	+070

COMPARISON OF OBSERVED WITH TABULAR PLACES (*continued*).

β ORIONIS.	Paris.	Greenwich.	Melbourne.	Brussels.	Oxford.	Edinburgh.	Washington, I.	Washington, II.	Harvard College.
	s.	s.	s.	s.	s.	s.	s.	s.	s.
1858	-.01	+.02						-.05	
1859	-.01	+.01		+.00				-.02	
1860	-.01	+.03	+.03	-.04	+.05			-.03	
1861	-.00	+.04			+.18	+.02		-.03	
1862	-.03	+.04		+.00	-.04	+.04	+.02		
1863	-.03	+.05	+.04	+.03	+.05	+.03	+.00		
1864	-.03	+.01	+.02	+.05	-.04	+.14	+.00		
1865	-.00	+.04	+.02	-.03	-.02	+.11	+.01		
1866	-.01	+.03	+.02		-.03	+.01	+.01		
1867		-.01	+.03		+.04	+.12	+.02		
1868		+.04	+.04		-.12	+.03	+.02		
1869		+.06			+.05	+.05	-.04		
1870		+.08			+.05		-.01		
1871									+.00
Means	-.014	+.034	+.029	+.002	+.015	+.062	+.003	-.032	+.000

β TAURI.									
1858	+.05	+.02		-.03				+.12	
1859	+.03	+.02		+.01				+.07	
1860	+.01	-.06	+.01	+.00	-.03	-.09		+.06	
1861	+.04	+.03		+.09	-.08	-.07		+.12	
1862	+.04	+.06		+.02	+.03	-.00	+.00		
1863	+.06	+.00		+.01	+.04	-.01	+.03		
1864	+.02	+.00	+.06	+.04	+.01	-.01	+.03		
1865	+.07	-.01	+.03	-(.13)	+.06	-.04	+.04		
1866	+.01	+.02	+.04	-.07	+.01	-.04	+.03		
1867		+.06	+.00		+.04	-.01	+.02		
1868		+.00	+.02			+.02	+.02		
1869		+.05			+.07		+.05		
1870		+.03			+.06		+.00		
1871									+.04
Means	+.037	+.017	+.027	+.009	+.021	-.026	+.024	+.092	+.040

α ORIONIS.									
1858	+.00	+.04		+.05					
1859	+.05	+.00		+.04				+.04	
1860	+.04	+.00	+.03	+.08	+.02	+.10		+.05	
1861	+.04	+.08		-.01	+.06	+.06		-.01	
1862	+.03	+.04		+.00	+.05	+.01	+.00		
1863	-.01	+.03	+.02	-.01	+.02	+.03	+.00		
1864	+.00	+.01	+.01	+(.09)	+.01	+.02	+.00		
1865	+.03	-.04	+.03	+.02	+.02	+.07	-.01		
1866	+.01	+.04	+.00	+.02	-.03	+.04	+.02		
1867		+.01	-.02		-.10	+.04	+.03		
1868		+.02	+.01		+.10	+.04	+.01		
1869		+(.14)			-.12	-.01	-.01		
1870		+.06			+.05		+.03		
1871									+.00
Means	+.021	+.024	+.011	+.024	+.007	+.040	+.008	+.027	+.000

COMPARISON OF OBSERVED WITH TABULAR PLACES (*continued*).

α CANIS MAJORIS.	Paris.	Green- wich.	Mel- bourne.	Brussels.	Oxford.	Edin- burgh.	Washing- ton, I.	Washing- ton, II.	Harvard College.
	s.	s.	s.	s.	s.	s.	s.	s.	s.
1858	+ .01	+ .03		— .02					
1859	— .01	+ .01		+ .01				— .06	
1860	+ .03	+ .03	+ .03	+ .03	+ .01			+ .01	
1861	— .01	+ .04		+ .05	+(.13)			— (.11)	
1862	+ .02	+ .04			+ .03		+ .00		
1863	+ .01		+ .01	— .04	+ .01		+ .00		
1864	+ .01	+ .05	+ .01	— .01	+(.21)		— .01		
1865	— .02	+ .03	+ .05	— .01			— .05		
1866	+ .00	+ .06	+ .04		+ .00		— .01		
1867		+ .02	+ .06		— .05		— .01		
1868		+ .05	+ .04				+ .12		
1869		+ .03			+ .07		+ .15		
1870		+ .07			+ .03		— .07		
1871									
Means	+ .004	+ .043	+ .034	+ .001	+ .014		+ .013	— .025	
α CANIS MINORIS.									
1858	+ .05	+ .05		+ .01				— .02	
1859	+ .02	+ .05		+ .01				— .01	
1860	+ .05	+ .03	+ .04	+ .00	+ .01	+ .02		— .02	
1861	+ .03	— .01		— .01	+ .06	+ .06		+ .01	
1862	+ .04	+ .03		+ .01	+ .04	+ .03	+ .00		
1863	+ .00	+ .01	+ .02	— (.07)	+ .00	+ .07	+ .01		
1864	+ .01	+ .03	— .02	— (.17)	— .03	+ .03	+ .02		
1865	— .02	+ .01	+ .00	— .00	+ .03	+ .10	— .09		
1866	— .02	+ .02	+ .03	+ .04	+ .02	+ .06	— .04		
1867		+ .02	+ .00		+ .04	+ .04	— .04		
1868		+ .01	+ .01		+ .03	+ .00	— .00		
1869		+ .04			— .02	+ .03	— .03		
1870		+ .04			+ .04		+ .03		
1871									+ .00
Means	+ .018	+ .026	+ .011	+ .009	+ .020	+ .044	— .016	— .010	+ .000
β GEMINORUM.									
1858	+ .04	+ .01		+ .05				+ .04	
1859	+ .03	+ .01		+ .03				+ .00	
1860	+ .02	— .02	— .01	+ .05	+ .02	+ .06		+ .03	
1861	+ .04	+ .03		+ .04	+(.37)	— .01		+ .03	
1862	+ .04	+ .01		+ .09	— .01	— .01	— .02		
1863	+ .02	+ .00		— .02	+ .04	— .02	— .01		
1864	+ .02	+ .00	+ .05		+(.15)	— .01	— .03		
1865	+ .00	— .02	+ .04	— .04		+ .02	— .02		
1866	+ .01	+ .04	— .01	— .04	+ .07	— .04	+ .04		
1867		+ .04	— .01		— .02	+ .00	+ .01		
1868		+ .02	+ .01		+ .03	+ .00	+ .02		
1869		+ .03			— .03	+ .00	— .01		
1870		+ .01			+ .00		+ .01		
1871									+ .01
Means	+ .024	+ .012	+ .012	+ .020	+ .012	— .001	— .001	+ .025	+ .010

COMPARISON OF OBSERVED WITH TABULAR PLACES (*continued*).

α HYDRÆ.	Paris.	Green- wich.	Mel- bourne.	Brussels.	Oxford.	Edin- burgh.	Washing- ton, I.	Washing- ton, II.	Harvard College.
1858	s. +.01	s. +.00	s.	s. -.05	s.	s.	s.	s.	s.
1859	-.08	-.01		+.03				-.01	
1860	+.00	+.06	+.02	+.01	+.02	+.13		+.03	
1861	-.02	+.05		+.01	-.01			-.01	
1862	+.02	+.06		+.04	+.00	+.07	+.00		
1863	-.02	+.03	+.06	-.04	+.02		-.03		
1864	+.01	-.02	+.02	+.03		+.09	+.01		
1865	-.01	-.01	-.01	+.01	+.02	+.09	-.03		
1866	-.02	-.01	-.03	-.02	-.07		+.02		
1867		+.01	+.02		+.01	+.07	+.01		
1868		-.01	+.03		+.02		-.02		
1869		+.00			+.01	+.05	-.02		
1870		+.02			+.07		-.03		
1871									-.01
Means	-.012	+.013	+.016	+.002	+.009	+.083	-.010	+.003	-.010

α LEONIS.									
1858	+.01	-.02		+.04				-.05	
1859	+.04	-.01		+.00				+.02	
1860	+.00	+.03	+.00	+.03	+.06	-.02		+.01	
1861	+.01	-.01		+.01	+.05	+.03		+.04	
1862	-.05	+.00		+.01	+.11	+.01	-.01		
1863	+.02	+.07		+.02	-.08	+.00	-.03		
1864	-.01	-.01	-.01	+.03	-.03	+.03	-.07		
1865	+.02	+.07	+.02	+.07	+.03	-.01	-.03		
1866	+.02	+.00	+.03		+.02	+.01	+.03		
1867		+.02	-.01		+.03	+.01	+.03		
1868		+.01	+.01		+.04	-.01	+.02		
1869		+.04			-.02	+.05	-.01		
1870		+.04			+.07		+.01		
1871									+.02
Means	+.007	+.018	+.007	+.026	+.025	+.010	-.007	+.005	+.020

β LEONIS.									
1858	+.02	-.01		+.03					
1859	+.05	+.00		+.03				+.05	
1860	+.01	-.01	+.02	+.01	+.00	+.02		+.06	
1861	+.06	+.00		+.03	-.03	-.02		+.09	
1862	+.00	+.05		+.05	+.06	-.01	-.02		
1863	+.06	+.02		+.02	+.00	+.01	+.00		
1864	+.02	+.00	+.04	+.02	+.03	+.00	-.04		
1865	-.01	+.02	+.04	+.04	+.01	-.01	+.00		
1866	+.00	-.01	+.08	+.06	+.00	+.00	+.01		
1867		-.01	+.05		-.01	-.01	+.01		
1868		+.03	+.05		+.10	+.02	+.00		
1869		+.00			-.09	+.02	-.03		
1870		+.02			+.05		+.01		
1871									+.03
Means	+.023	+.008	+.047	+.032	+.011	+.002	-.007	+.067	+.030

COMPARISON OF OBSERVED WITH TABULAR PLACES (*continued*).

α VIRGINIS.	Paris.	Greenwich.	Melbourne.	Brussels.	Oxford.	Edinburgh.	Washington, I.	Washington, II.	Harvard College.
	s.	s.	s.	s.	s.	s.	s.	s.	s.
1858	+.01	+.02		+.03				— .02	
1859	+.04	+.05		+.07				+.06	
1860	+.03	+.04	+.04	+.08	+.01			+.04	
1861	+.00	+.02		+.05	— .03			+.01	
1862	+.01	+.01		+.04	(.14)		— .01		
1863	+.00	+.03	+.03	+.10	+.00	+.16	— .01		
1864	— .01	+.04	+.04	+.07	+.01	+.09	— .02		
1865	— .01	+.02	+.04		— .02		— .03		
1866	+.09	+.03	+.01	+.01	— .04	+.10	— .00		
1867		+.03	+.02			+.08	— .01		
1868		+.05	+.05			+.03	— .00		
1869		+.02			+.07		— .00		
1870		+.10			— .04		+.02		
1871									+.03
Means	+.018	+.035	+.033	+.056	— .005	+.075	— .007	+.023	+.030

α BOOTIS.									
1858	+.03	+.02		+.06				+.07	
1859	+.03	+.01		+.07				+.03	
1860	+.04	+.02	+.06	+.06	+.08	+.00		+.08	
1861	+.06	+.03		+.04	+.01	+.04		+.11	
1862	+.11	+.03		+.02	+.05	+.05	+.01		
1863	+.03	+.04	+.05	+.11	— .02	+.01	+.02		
1864	+.03	+.00	+.10		— .09	+.02	— .01		
1865	+.07	+.04	+.10	+.04	— .03	— .03	+.02		
1866	+.06	+.04	+.03	+.04	+.04	+.03	+.03		
1867		+.03	+.05		+.01	+.02	+.02		
1868		+.05	+.07		— .03	+.00	+.03		
1869		+.05			+.01	+.02	— .01		
1870		+.08			+.05		+.02		
1871									+.02
Means	+.051	+.034	+.066	+.055	+.007	+.016	+.014	+.072	+.020

α^2 LIBRÆ.									
1858	+.00	+.05		+.11	+.03				
1859	— .01	+.07		+.01	+.05			+.07	
1860	+.04	+.06	+.07	+.09	+.02			+.06	
1861	+.02	+.04		+.07	+.04			+.06	
1862	+.02	+.03		+.13	+.06		+.03		
1863	+.02	+.04	+.02	+.12	— .02		+.03		
1864	+.02	+.04	+.04	+.04	+.02		+.05		
1865	+.04	+.02	+.02	+.10	+.01		+.02		
1866	+.06	+.01	+.03	+.00	— .02		+.00		
1867		— .01	+.04		— .01		+.00		
1868		+.06	+.06		+.00		+.01		
1869		+.00					— .03		
1870		+.01					+.01		
1871									— .02
Means	+.023	+.032	+.040	+.074	+.016		+.013	+.063	— .020

COMPARISON OF OBSERVED WITH TABULAR PLACES (*continued*).

α CORONÆ.	Paria.	Green- wich.	Mel- bourne.	Brussels.	Oxford.	Edin- burgh.	Washing- ton, I.	Washing- ton, II.	Harvard College.
	s.	s.	s.	s.	s.	s.	s.	s.	s.
1858	+03	+01		+06				+09	
1859	+06	+02		+10				+11	
1860	+07	+00	+06	+05	+02	—01		+12	
1861	+09	+02		+03	+02	+03		+12	
1862	+08	+00		+04	+04	—01	+02		
1863	+06	+02	+06	+12	—01	—01	+04		
1864	+08	+03	+13	+06	+01	—01	—01		
1865	+05	+03	+07	+05	+02	—03	+02		
1866	+04	+03	+09	+05	+01	—01	+04		
1867		+02			+08	+00	+01		
1868		+04	+08		—(010)	+01	+04		
1869		+03			+01	—01	+00		
1870		+06			+00		+01		
1871									+04
Means	+062	+024	+082	+062	+020	—005	+019	+110	+040

α SERPENTIS.									
1858	+05	+03		+04					
1859	+04	+03		+10				+08	
1860	+06	+03	+06	+05	+04	+03		+08	
1861	+06	+02		+04	+05			+09	
1862	+02	+06		+08	—02	+03	+03		
1863	+04	+06	+08	+04	+01	+04	+03		
1864	+02	+04	+06	+05	+04	+08	—(04)		
1865	+05	+02	+07	+12	+01	+05	+06		
1866	+02	+05	+09		+04	+04	+02		
1867		+00	+06		+06	+05	—01		
1868		+04	+09		+09	+06	+01		
1869		+08			+00	+06	—01		
1870		+07			+05		+02		+02
1871									
Means	+040	+041	+073	+065	+034	+049	+019	+083	+020

α SCORPII.									
1858	+00	+03		+06				—02	
1859	—02	+07		+10				+05	
1860	—03	+09	+06	+10	+02			+05	
1861	—02	+04		+10	+01			+01	
1862	—03	+05		+08	+07		+01		
1863	—00	—02	+03	+06	+06		+00		
1864	—01		+06	+09	+07		+00		
1865	—01	+04	+08	+04	—02		+02		
1866	+03	—01	+03	+01	—01		—02		
1867		+00	+08		—01		—05		
1868		+04	+08				+01		
1869		+03			—03		—03		
1870		+00			+06		+06		
1871									+01
Means	—010	+030	+060	+071	+022		+000	+022	+010

COMPARISON OF OBSERVED WITH TABULAR PLACES (*continued*).

α HERCULIS.	Paris.	Greenwich.	Melbourne.	Brussels.	Oxford.	Edinburgh.	Washington, I.	Washington, II.	Harvard College.
	s.	s.	s.	s.	s.	s.	s.	s.	s.
1858	+ .05	+ .05						+ .07	
1859	+ .04	— .07		+(.14)				+ .10	
1860	+ .06	+ .02	+ .06	+ .06	+ .12	+ .07		+ .09	
1861	+ .04	+ .07		+(.17)	+(.18)	+ .02		+ .09	
1862	+ .07	— .04		+ .10	+ .09	— .02	+ .01		
1863	+ .07	+ .09	+ .05	+ .18	+ .06	+ .05	+ .01		
1864	+ .06	— .02	+ .08	+(.22)	+ .03	— .01	+ .03		
1865	+ .04	+ .02	+ .11	+ .10	+ .03	+ .04	+ .02		
1866	+ .04	+ .01	+ .09	+ .13	+ .07	+ .03	+ .01		
1867		+ .01	+ .11		+ .08	— .01	+ .01		
1868		+ .04	+ .08		+(.20)	+ .02	+ .00		
1869		+ .02			+ .00	+ .04	— .01		
1870		+ .02			+ .06		+ .04		
1871									+ .03
Means	+ .052	+ .017	+ .083	+ .114	+ .060	+ .023	+ .013	+ .087	+ .030

α OPHIUCHI.									
1858	+ .06	+ .03		+ .12				+ .06	
1859	+ .05	+ .03		+ .09				+ .10	
1860	+ .04	+ .02	+ .09	+ .11	+ .11	+ .01		+ .11	
1861	+ .05	+ .05			+ .10	+ .08		+ .10	
1862	+ .09	+ .03		+ .09	+ .04	+ .03	+ .03		
1863	+ .05	— .01	+ .07	+ .09	+ .04	+ .04	+ .03		
1864	+ .04	+ .02	+ .09	+ .14	+ .02	+ .06	+ .06		
1865	+ .07	+ .02	+ .10	+ .06	+ .01	+ .04	+ .04		
1866	+ .07	+ .03	+ .09		+ .06	+ .09	+ .04		
1867		+ .02	+ .11		+ .02	+ .06	+ .00		
1868		+ .04	+ .10		+ .01	+ .02	+ .02		
1869		+ .04			+ .06	+ .10	+ .04		
1870		+ .04			— .01		+ .03		
1871									+ .02
Means	+ .058	+ .028	+ .093	+ .100	+ .042	+ .053	+ .032	+ .092	+ .020

α LYRÆ.									
1858	+ .07	— .03							
1859	+ .08	+ .06		+ .03				+ .14	
1860	+ .08	+ .07	+ .08	+ .09	+ .04	+ .02		+ .15	
1861	+ .06	+ .03		+ .03	+ .13	+ .09		+ .17	
1862	+ .12	+ .04		+ .11	+ .07		+ .03		
1863	+ .08	+ .02	+ .04	+ .04	+ .11	+ .02	+ .04		
1864	+ .10	+ .03	+(.18)	+ .15	— .05	+ .04	+ .02		
1865	+ .10	+ .04	+(.17)	+ .10	+ .06	+ .07	+ .04		
1866	+ .12	+ .03	+ .10	+ .10	+ .02	+ .06	+ .02		
1867		+ .03	+ .10		+ .09	+ .04	+ .01		
1868		+ .04	+ .09		— .04	+ .04	+ .04		
1869		+ .04			+ .07	+ .03	+ .01		
1870		+ .08			+ .08		+ .03		
1871									+ .03
Means	+ .090	+ .037	+ .082	+ .081	+ .053	+ .046	+ .027	+ .153	+ .030

COMPARISON OF OBSERVED WITH TABULAR PLACES (*continued*).

γ AQUILÆ.	Paris.	Greenwich.	Melbourne.	Brussels.	Oxford.	Edinburgh.	Washington, I.	Washington, II.	Harvard College.
1858	s. +.07	s. +.01	s.	s. +.12	s.	s.	s.	s. +.10	s.
1859	+ .11	+ .06		+ .10				+ .10	
1860	+ .05	+ .03	+ .11	+ .11	+ .12	+ .10		+ .11	
1861	+ .07	+ .03		+ .10	+ .13	+ .09		+ .12	
1862	+ .04	+ .06		+ (.19)	+ .05	+ .08	+ .04		
1863	+ .08	+ .05	+ .12	+ .09	+ .07	+ .06	+ .05		
1864	+ .07	+ .07	+ .10	+ .10	+ .09	+ .08	+ .02		
1865	+ .07	+ .07	+ .11	+ .09	— .02	+ .03	+ .04		
1866	+ .04	+ .04	+ .12	+ .06	+ .02	+ .05	+ .01		
1867		+ .05	+ .07		+ .04	+ .06	+ .04		
1868		+ .06	+ .15		+ .10	+ .04	+ .03		
1869		+ .04			+ .03	+ .10	— .06		
1870		+ .03			+ .03		+ .01		
1871									+ .02
Means	— .067	+ .050	+ .111	+ .096	+ .060	+ .069	+ .020	+ .108	+ .020

α AQUILÆ.									
1858	+ .04	+ .02		+ .06				+ .08	
1859	+ .05	+ .03		+ .06				+ .08	
1860	+ .07	— .01	+ .08	+ .09	+ .06	+ .11		+ .09	
1861	+ .06	+ .03		+ .08	+ .06	+ .07		+ .09	
1862	+ .08	+ .05		+ .09	+ .09	+ .09	+ .02		
1863	+ .06	+ .06	+ .08	+ .09	+ .01	+ .04	+ .02		
1864	+ .05	+ .03	+ .10	+ .06	+ .07	+ .06	+ .04		
1865	+ .03	+ .02	+ .12		+ .00	+ .04	+ .04		
1866	+ .06	— .02	+ .09	+ .05	+ .01	+ .03	— .02		
1867		+ .04	+ .09		— (.09)	+ .06	+ .00		
1868		+ .03	+ .08		+ .04	+ .03	+ .01		
1869		+ .01			+ .03	+ .05	— .04		
1870		+ .04			+ .04		+ .02		
1871									+ .04
Means	+ .056	+ .025	+ .091	+ .073	+ .041	+ .058	+ .010	+ .085	+ .040

β AQUILÆ.									
1858	+ .07	+ .05		+ .12				+ .06	
1859	+ .09	+ .01		+ .12				+ .10	
1860	+ .10	+ .08	+ .10		+ .00	+ .10		+ .11	
1861	+ .06	+ .06		+ .12	— .02	+ .04		+ .11	
1862	+ .03	+ .03		+ .10	— .03	+ .06	+ .05		
1863	+ .08	+ .03	+ .13	+ (.16)	+ .10	+ .07	+ .05		
1864	+ .06	+ .06	+ .09	+ .10	+ .02	+ .05	+ .00		
1865	+ .07	+ .06	+ .08	+ .08	+ .06	+ .06	+ .05		
1866	+ .09	+ .06	+ .13	+ .12	+ .08	+ .08	+ .02		
1867		+ .04	+ .10		+ .17	+ .00	+ .04		
1868		+ .06	+ .09		+ .07	+ .04	+ .03		
1869		+ .04			+ .06	+ .04	— .08		
1870		+ .07			+ .02		+ .00		
1871									+ .04
Means	+ .072	+ .050	+ .103	+ .109	+ .048	+ .054	+ .018	+ .095	+ .040

COMPARISON OF OBSERVED WITH TABULAR PLACES (*continued*)

α^2 CAPRI-CORNI.	Paris.	Greenwich.	Melbourne.	Brussels.	Oxford.	Edinburgh.	Washington, I.	Washington, II.	Harvard College.
	s.	s.	s.	s.	s.	s.	s.	s.	s.
1858	+06	+08		+04				+13	
1859	+01	+10		+13				+13	
1860	—02	+05	+09	+17	+01		+08	+09	
1861	+02	+05		+13	—09		+05	+11	
1862	+09	+08		+17	+04		+09		
1863	+09	+04	+07	+13	+03		+05		
1864	+04	+03	+05	+17	+12		+02		
1865	+06	+06	+04	+20	+11		—03		
1866	+05	+01	+08	+13	+05		+02		
1867		+03	+12		+08				
1868		+04	+06		+06		+02		
1869		+04			+11				
1870		+03			+05				
1871									
Means	+044	+049	+073	+141	+052		+038	+115	
α CYGNI.									
1858	+10	—01		+04				+06	
1859	+10	+05		+01				+03	
1860	+02	+10	+10	+07	+14			+05	
1861	+07	—(05)		+(24)	—06			+16	
1862	+11	—01		+12	+(25)		+02		
1863	+(14)	+03	+19	+06	—02	+02	+02		
1864	+12	—(07)	+11	+08	+05	+09	+03		
1865	+(14)	+02	+09	+12	+08		+05		
1866	+11	+04		+11	+11		+07		
1867		+07	+00		+05		—03		
1868		+02			+03		+06		
1869		—(07)			+11	—(10)	+10		
1870		+07			+11		—07		
1871									+04
Means	+090	+038	+098	+076	+060	+055	+028	+075	+040
α AQUARI.									
1858	+07	+06		+09				+09	
1859	+06	+08		+09				+09	
1860	+06	+06	+08	+09	+07	+04		+11	
1861	+08	+04		+12	+00	+06		+10	
1862	+05	+04		+11	+07	+06	+06		
1863	+08	+09	+06	+08	+09	+07	+06		
1864	+06	+07	+07		+04	+10	+07		
1865	+09	+08	+07	+12	—01	+11	+03		
1866	+05	+04	+04			+11	+01		
1867		+08	+08		+06	+08	+01		
1868		+06	+08		+09	+14	+00		
1869		+05			+05	+11	+00		
1870		+04			+06		—01		
1871									+00
Means	+067	+061	+069	+100	+052	+088	+026	+098	+000

COMPARISON OF OBSERVED WITH TABULAR PLACES (*continued*).

α PISCIS AUSTRALIS.	Paria.	Green- wich.	Mel- bourne.	Brussels.	Oxford.	Edin- burgh.	Washing- ton, I.	Washing- ton, II.	Harvard College.
1858	s. +.07	s. +.11	s.	s. -.01	s.	s.	s.	s. +.11	s.
1859	+.02	+.08		+.20				+.11	
1860	+.13	+.09	+.06	+.09	+.06			+.09	
1861	+.04	+.08		+.22	+.10			+.03	
1862	-.06	+.09		+.09	+.03		+.05		
1863		+.09	+.07		+.27		+.06		
1864	+.09	+.01	+.11	+.15	+.08		+.03		
1865	+.06	+.05	+.10	+.03	+.05		-.01		
1866	+.08	+.10	+.06	+.13			+.02		
1867		+.07	+.05		-.04		-.05		
1868		+.04	+.10		+.01		-.02		
1869		+.07			+.13				
1870		+.04			+.08		-.06		
1871									-.03
Means	+.070	+.071	+.079	+.080	+.056		+.002	+.085	-.030

α PEGASI.									
1858	+.04	+.02		+.13				+.05	
1859	+.03	+.07		+.07				+.04	
1860	+.08	+.04	+.08	+.07	+.04	+.05		+.09	
1861	+.06	+.01		+.07	+.07	+.04		+.08	
1862	+.09	-.01		+.12	+.08	+.04	+.02		
1863	+.09	+.09	+.08	+.08	+.12	+.04	+.03		
1864	+.08	+.04	+.08		+.10	+.03	+.00		
1865	+.07	+.05	+.12	+.08	+.06	+.04	+.03		
1866	+.11	+.04	+.07	+.06	-.07	+.04	+.00		
1867		+.01	+.09		+.01	+.07	+.02		
1868		+.02	+.10		+.14	+.04	+.01		
1869		+.08			+.04	+.03	-.02		
1870		+.05			+.04		-.01		
1871									+.01
Means	+.072	+.039	+.089	+.085	+.057	+.042	+.009	+.065	+.010

The following tables contain:—

TABLE I.

The residuals, in thousandths of seconds, obtained by subtracting the observed from the computed places, after applying, in each case, the correction for equinox, ϵ , which is obtained by dividing the difference between the sum of the positive and the negative corrections by 30, the number of stars employed. In the first approximation, neither α Canis Majoris nor α Piscis Australis will be used, the results for these stars being included in brackets.

For Greenwich	$\epsilon = +.029$
Washington, I.	$= +.011$
Washington, II.	$= +.062$
Paris	$= +.039$
Melbourne	$= +.057$
Brussels	$= +.061$
Oxford	$= +.032$
Edinburgh	$= +.039$
Harvard College	$= +.023$

The sum of the residuals for each observatory is designated by $[v]$.

TABLE II.

The residuals, arranged in order of declination, obtained by subtracting from the residuals in Table I. the periodic errors of single period, derived from the following normal equations for the mean date 1864:—

For Greenwich . . .	$17.58 m + .26 n = \Sigma r \sin \alpha = -.189$	$m = -.011$
	$.26 m + 12.32 n = \Sigma r \cos \alpha = +.100$	$n = +.008$
For Washington, I. . .	$17.58 m + .26 n = \Sigma r \sin \alpha = -.159$	$m = -.009$
	$.26 m + 12.32 n = \Sigma r \cos \alpha = +.119$	$n = +.010$
For Washington, II. . .	$17.58 m + .26 n = \Sigma r \sin \alpha = -.640$	$m = -.037$
	$.26 m + 12.32 n = \Sigma r \cos \alpha = +.247$	$n = +.021$
For Paris	$17.58 m + .26 n = \Sigma r \sin \alpha = -.379$	$m = -.022$
	$.26 m + 12.32 n = \Sigma r \cos \alpha = +.266$	$n = +.022$
For Melbourne	$17.58 m + .26 n = \Sigma r \sin \alpha = -.593$	$m = -.034$
	$.26 m + 12.32 n = \Sigma r \cos \alpha = +.249$	$n = +.021$
For Brussels	$17.58 m + .26 n = \Sigma r \sin \alpha = -.661$	$m = -.038$
	$.26 m + 12.32 n = \Sigma r \cos \alpha = +.252$	$n = +.021$
For Oxford	$17.58 m + .26 n = \Sigma r \sin \alpha = -.226$	$m = -.013$
	$.26 m + 12.32 n = \Sigma r \cos \alpha = +.262$	$n = +.022$
For Edinburgh	$14.67 m - .39 n = \Sigma r \sin \alpha = -.136$	$m = -.009$
	$.39 m + 11.23 n = \Sigma r \cos \alpha = +.107$	$n = +.010$
For Harvard College . .	$16.87 m + .71 n = \Sigma r \sin \alpha = -.019$	$m = -.001$
	$.71 m + 12.03 n = \Sigma r \cos \alpha = +.106$	$n = +.009$

TABLE I.

	δ	Green- wich.	Wash- ton, I.	Wash- ton, II.	Paris.	Mel- bourne.	Bruss'ls.	Oxford.	Edin- burgh.	Harv'd College.
α Andromedæ . . .	0	— 8	+ 12	+ 28	+ 21	+ 17	+ 19	+ 34	— 3	+ 27
γ Pegasi	+ 7	+ 4	+ 0	+ 17	+ 10	+ 2	+ 30	— 21	— 13
α Arietis	+ 3	+ 5	+ 4	+ 8	+ 13	+ 15	— 16	— 7	+ 27
α Ceti	— 2	— 25	+ 0	— 3	— 8	— 14	— 1	+ 24	+ 7
α Tauri	— 14	— 3	— 32	— 21	— 18	— 30	— 15	— 15	+ 7
α Aurigæ	— 18	+ 8	— 24	— 28	— 55	— 15	+ 6	— 17	+ 47
β Orionis	+ 5	— 8	— 94	— 53	— 28	— 59	— 17	+ 23	— 23
β Tauri	— 12	+ 13	+ 30	— 2	— 30	— 52	— 11	— 65	— 23
α Orionis	— 5	— 3	— 35	— 18	— 46	— 37	— 25	+ 1	— 23
[α Canis Majoris	+ 14	+ 2	— 87	— 35	— 23	— 60	— 18	...	...
α Canis Minoris	— 3	— 27	— 72	— 21	— 46	— 52	— 12	+ 5	— 23
β Geminorum	— 17	— 12	— 37	— 15	— 45	— 41	— 20	— 40	— 13
α Hydræ	— 16	— 21	— 59	— 51	— 41	— 59	— 23	+ 44	— 33
α Leonis	— 11	— 18	— 57	— 32	— 50	— 35	— 7	— 29	— 3
β Leonis	— 21	— 18	+ 5	— 16	— 10	— 29	— 21	— 37	+ 7
α Virginis	+ 6	— 18	— 37	— 21	— 24	— 5	— 37	+ 39	+ 7
α Bootis	+ 5	+ 3	+ 10	+ 12	+ 9	— 6	— 25	— 23	— 3
α^2 Libræ	+ 3	+ 2	+ 1	— 16	— 17	+ 13	— 16	...	— 43
α Coronæ	— 5	+ 8	— 48	+ 23	+ 25	+ 1	— 12	— 44	+ 17
α Serpentis	+ 12	+ 8	+ 21	+ 1	+ 16	+ 4	+ 2	+ 10	— 3
α Scorpii	+ 1	— 11	— 40	— 49	+ 3	+ 10	— 10	...	— 13
α Herculis	— 12	+ 2	+ 25	+ 13	+ 26	+ 53	+ 28	— 16	+ 7
α Ophiuchi	— 1	+ 21	+ 30	+ 19	+ 36	+ 39	+ 10	+ 14	— 3
α Lyræ	+ 8	+ 16	+ 91	+ 51	+ 25	+ 20	+ 21	+ 7	+ 7
γ Aquilæ	+ 21	+ 9	+ 46	+ 28	+ 54	+ 35	+ 28	— 30	— 3
α Aquilæ	— 4	+ 1	— 23	+ 17	+ 34	+ 12	— 9	+ 19	+ 17
β Aquilæ	+ 21	+ 7	— 33	+ 33	— 46	+ 48	+ 16	+ 15	+ 17
α^2 Capricorni	+ 20	+ 27	+ 53	+ 5	+ 16	+ 80	+ 20	...	...
α Cygni	+ 9	+ 17	+ 13	+ 51	+ 41	+ 15	+ 28	+ 16	+ 17
α Aquarii	+ 32	+ 15	+ 36	+ 28	+ 12	+ 39	+ 20	+ 49	— 23
[α Piscis Australis	+ 42	— 9	+ 23	+ 31	+ 22	+ 19	+ 24	— 53	— 53
α Pegasi	+ 10	— 2	+ 3	+ 33	+ 32	+ 24	+ 25	+ 3	— 13
[v]		+ 163 — 149	+ 177 — 167	+ 496 — 491	+ 360 — 346	+ 415 — 418	+ 427 — 436	+ 277 — 268	+ 299 — 300	+ 228 — 235

TABLE II.

	δ	+ 31	— 21	— 7	+ 3	— 8	— 12	— 1	...	— 62
[α Piscis Australis . . .	— 30.3	+ 6	— 15	— 66	— 60	— 19	— 16	— 13	...	— 10
α Scorpii . . .	— 26.1	+ 25	+ 13	— 47	— 9	+ 15	— 18	— 1	...	...
[α Canis Majoris . . .	— 16.5	+ 2	+ 4	— 8	— 13	+ 23	+ 4	— 7	...	— 37
α^2 Libræ . . .	— 15.5	+ 7	+ 14	+ 11	— 25	— 24	+ 37	— 3	...	...
α^2 Capricorni . . .	— 12.9	+ 10	— 12	— 30	— 7	— 15	+ 2	— 20	+ 42	+ 15
α Virginis . . .	— 10.5	+ 14	— 1	— 62	— 37	+ 0	— 31	— 9	+ 29	— 24
β Orionis . . .	— 8.3	+ 3	— 7	— 20	— 20	— 3	— 19	+ 2	+ 58	— 25
α Hydræ . . .	— 8.1	+ 20	+ 3	+ 1	— 2	— 23	+ 2	— 5	+ 37	— 31
α Aquarii . . .	— 1.0	+ 0	+ 26	+ 11	— 5	+ 0	— 3	+ 6	+ 23	+ 2
α Ceti . . .	+ 3.6	+ 10	— 15	— 30	+ 8	— 7	— 9	+ 9	+ 17	— 18
α Canis Minoris . . .	+ 5.6	+ 7	— 6	— 9	+ 3	+ 6	+ 11	— 6	+ 2	+ 12
β Aquilæ . . .	+ 6.1	+ 8	+ 7	+ 3	+ 4	+ 0	— 15	+ 4	+ 9	+ 1
α Serpentis . . .	+ 6.8	+ 6	+ 6	+ 1	+ 4	— 13	+ 0	— 13	+ 10	— 22
α Orionis . . .	+ 7.4	— 18	— 13	— 19	— 12	— 6	— 31	— 13	+ 7	+ 12
α Aquilæ . . .	+ 8.5	+ 8	— 3	+ 4	— 1	+ 14	— 9	+ 7	+ 18	— 8
γ Aquilæ . . .	+ 10.3	+ 2	— 5	— 22	— 2	— 15	+ 2	+ 18	— 16	+ 3
α Leonis . . .	+ 12.6	+ 11	+ 13	+ 4	+ 0	+ 5	+ 4	+ 0	+ 6	+ 6
α Ophiuchi . . .	+ 12.7	— 1	— 6	— 19	— 6	— 10	— 22	+ 8	— 31	— 22
γ Pegasi . . .	+ 14.5	— 1	— 14	— 26	+ 6	+ 3	— 6	+ 1	— 9	— 22
α Pegasi . . .	+ 14.5	— 21	— 5	— 7	— 3	— 2	+ 21	+ 20	— 23	+ 8
α Herculis . . .	+ 15.3	— 12	— 7	+ 28	+ 8	+ 14	— 5	+ 2	+ 26	+ 16
β Leonis . . .	+ 16.2	+ 8	+ 1	— 6	— 10	+ 5	— 3	— 12	— 11	+ 4
α Tauri . . .	+ 19.9	+ 6	+ 6	+ 7	+ 19	+ 9	— 9	— 13	— 20	+ 4
α Bootis . . .	+ 22.8	+ 1	+ 0	— 3	+ 0	+ 12	+ 16	— 29	— 12	+ 20
α Arietis . . .	+ 27.2	— 9	+ 7	+ 31	+ 19	+ 11	— 16	— 9	— 45	+ 21
α Coronæ . . .	+ 28.3	— 16	+ 2	+ 8	— 1	— 4	— 2	+ 12	— 13	+ 18
α Andromedæ . . .	+ 28.4	— 4	+ 0	+ 5	+ 14	— 6	+ 3	+ 1	— 28	— 8
β Geminorum . . .	+ 28.5	— 2	+ 20	+ 62	+ 16	— 1	— 19	— 2	— 58	+ 16
β Tauri . . .	+ 38.7	— 4	+ 6	+ 51	+ 26	— 12	— 21	+ 5	— 3	+ 5
α Lyræ . . .	+ 44.8	— 5	+ 4	+ 29	+ 20	+ 1	— 28	+ 4	+ 3	+ 10
α Cygni . . .	+ 46.0	— 9	+ 15	+ 7	— 12	— 27	+ 17	+ 14	...	+ 46
[v]		+ 101 — 130	+ 108 — 135	+ 230 — 360	+ 143 — 220	+ 80 — 210	+ 119 — 264	+ 113 — 154	+ 261 — 295	+ 216 — 230

It is quite obvious, from simple inspection, that in the case of Paris, Edinburgh, Washington II., and Harvard College, the corrections depending on the Declination are quite large, while in every other case they are of sufficient magnitude to be recognizable.

For each residual, r'' , of Table II., there will be an equation of the form:—

$$r'' = a \sin \delta + b \cos \delta,$$

from which a and b are to be found.

For a first approximation it will be allowable to arrange the equations in groups, in each of which r'' , $\sin \delta$ and $\cos \delta$ are understood to be mean values. The following are the limits of the groups:—

Group I.	. . . . .	from -30° to -8°
Group II.	. . . . .	from -1° to $+10^\circ$
Group III.	. . . . .	from $+12^\circ$ to $+23^\circ$
Group IV.	. . . . .	from $+27^\circ$ to $+46^\circ$

α Piscis Australis and α Canis Majoris will now be included in the discussion.

EQUATIONS.

	Green- wich.	Washington, I. II.	Paris.	Mel- bourne.	Brus- sels.	Oxford.
Group I.	$-.27 a + .95 b = +10$	$-4 \quad -29$	-21	-10	-7	-6
Group II.	$+.10 a + .99 b = +5$	$-5 \quad -5$	-1	-4	-7	-1
Group III.	$+.27 a + .96 b = -5$	$-3 \quad -6$	$+1$	$+2$	$+0$	$+0$
Group IV.	$+.56 a + .83 b = -6$	$+8 \quad +19$	$+12$	-5	-9	$+3$

	Edinburgh.	Harvard College.
Group I.	$-.15 a + .99 b = +13$	$-.28 a + .95 b = -24$
Group II.	$+.10 a + .99 b = +15$	$+.10 a + .99 b = -7$
Group III.	$+.27 a + .96 b = -16$	$+.27 a + .96 b = +1$
Group IV.	$+.53 a + .85 b = -24$	$+.56 a + .83 b = +15$

From these equations, we have by least-squares the following values of a and b :—

For Greenwich	$a = -.021$	$b = +.005$
Washington, I.	$a = +.015$	$b = -.005$
Washington, II.	$a = +.056$	$b = -.016$
Paris	$a = +.039$	$b = -.009$
Melbourne	$a = +.008$	$b = -.006$
Brussels	$a = -.005$	$b = -.004$
Oxford	$a = +.013$	$b = -.004$
*Edinburgh	$a = -.101$	$b = +.025$
Harvard College	$a = +.044$	$b = -.014$

Computing the values of r'' with these coefficients, and subtracting from the residuals of Table II., we have Table III., arranged in order of Right Ascensions.

* The discussion of a series of equations of the form $r'' = a \frac{\sin z}{\cos \delta} + b \frac{\cos z}{\cos \delta} + \frac{c}{\cos \delta}$ gave results nearly identical with these.

TABLE III.

	Green- wich.	Wash- gton, I.	Wash- gton, II.	Paris.	Mel- bourne.	Brus- sels.	Oxford.	Edin- burgh.	Harv'd College.
α Andromedæ . .	-10	-1	-4	-11	-3	+4	+10	+12	+9
γ Pegasi	-1	-5	-17	-7	-6	-17	+9	-30	-19
α Arietis	+4	-1	-10	-7	+15	+22	-30	+4	+16
α Ceti	-4	-22	+24	+2	+6	+1	+9	+4	+13
α Tauri	-7	+2	-7	-12	+9	+2	-12	-7	+5
α Aurigæ	+3	+7	-22	-34	-29	+24	+8	...	+22
β Orionis	+6	+6	-38	-23	+7	-28	-3	-10	-4
β Tauri	+4	+17	+50	+6	+0	-13	-4	-33	+7
α Orionis	+4	+9	+10	+8	+8	+5	-11	-2	-14
α Canis Majoris .	+14	+22	-16	+11	+23	-15	+7	...	...
α Canis Minoris .	+7	-12	-20	+13	-2	+5	+12	+2	-8
β Geminorum . .	+2	-3	-7	+4	+5	+9	-1	-3	-18
α Hydræ	-11	+10	+4	-6	+4	-16	+8	+19	-5
α Leonis	+2	-3	-18	-2	-11	+7	+19	-19	+10
β Leonis	-12	-6	+28	+7	+18	+0	+3	-24	+19
α Virginis	+1	-4	-4	+9	-5	+5	-14	-1	+37
α Bootis	+8	+6	+3	+15	+12	-3	-13	-10	+2
α^2 Libræ	-9	+13	+22	+7	+15	+7	+0	...	-12
α Coronæ	-3	+5	+19	+9	+12	-10	-11	-21	+13
α Serpentis . . .	+6	+10	+12	+0	+5	-10	+6	-4	+10
α Scorpil	-19	-4	-27	-35	-11	-14	-3	...	+22
α Herculis	-21	-4	-5	-4	+2	+26	+21	-22	+11
α Ophiuchi . . .	-11	+15	+0	+0	+9	+9	+1	+3	+1
α Lyræ	+5	+1	+30	+9	-11	-14	+1	+39	-11
γ Aquilæ	+7	-1	+10	+1	+18	-4	+9	+11	-2
α Aquilæ	-20	-10	-11	-9	-1	-26	-11	-3	+19
β Aquilæ	+4	-3	+1	+8	+11	+15	-3	-12	+20
α^2 Capricorni . .	-3	+22	+39	-7	-16	+40	+4	...	...
α Cygni	+6	-2	-57	-1	-1	-21	-2	+56	-11
α Aquarii	+15	+8	+18	+8	-17	+5	-1	-10	-17
α Piscis Australis	+17	-10	+35	+30	+1	-11	+8	...	-28
α Pegasi	-1	-13	-24	+5	+7	-1	+2	-8	-19
[v]	+115 -132	+143 -104	+305 -287	+152 -158	+159 -144	+181 -208	+137 -119	+150 -219	+236 -168

The assignment of weights to observations is necessarily somewhat a matter of individual judgment. The following empirical formula, though not free from objection, will be adopted:—

Let w' = the quotient obtained by dividing the square root of the number of years of observation for any observatory, by $\sqrt{13}$.

w'' = the quotient obtained by dividing 10 $[v]$ for Greenwich by $[v]$ for any other observatory.

Then the weight,

$$w = \frac{w' + w''}{2}.$$

By this formula we have, after increasing the values for Edinburgh and Harvard College proportionately,—

	[v]	w''	w'	w
For Greenwich	2941	10.0	10.0	10
Washington, I.	3168	9.3	8.3	9
Washington, II.	17172	1.7	2.0	2
Paris	5490	5.4	8.3	7
Melbourne	4331	6.8	7.2	7
Brussels	7509	3.9	8.3	6
Oxford	3418	8.6	9.2	9
Edinburgh	13023	2.3	8.9	6
Harvard College	7834	3.8	1.0	2

Assigning to the residuals in Table III. the weights w , and taking the means, we have (omitting for the present the discussion of errors of double period) the following system of corrections, as shown in Table IV.

TABLE IV.

	Assumed correction to Newcomb.	Derived correction to assumed R. A.	Derived correction to Newcomb.	Adopted correction to Newcomb.
<i>a</i> Andromedæ	+ 0	+ 0	+ 0	— 3
<i>γ</i> Pegasi	—10	+ 7	— 3	— 6
<i>a</i> Arietis	+ 0	+ 0	+ 0	— 3
<i>a</i> Ceti	+ 0	+ 0	+ 0	— 3
<i>a</i> Tauri	+ 0	+ 4	+ 4	+ 1
<i>a</i> Aurigæ	—20	+ 2	—18	—21
<i>β</i> Orionis	+10	+ 6	+16	+13
<i>β</i> Tauri	+10	— 1	+ 9	+ 6
<i>a</i> Orionis	+10	— 1	+ 9	+ 6
<i>a</i> Canis Majoris	+20	—10	+10	+ 7
<i>a</i> Canis Minoris	+10	— 1	+ 9	+ 6
<i>β</i> Geminorum	+ 0	+ 1	+ 1	— 2
<i>a</i> Hydræ	+ 0	+ 1	+ 1	— 2
<i>a</i> Leonis	+ 0	+ 0	+ 0	— 3
<i>β</i> Leonis	+ 0	+ 0	+ 0	— 3
<i>a</i> Virginis	+ 0	+ 1	+ 1	— 2
<i>a</i> Bootis	+10	— 3	+ 7	+ 4
<i>α</i> ² Libræ	+10	— 1	+ 9	+ 6
<i>a</i> Coronæ	+ 0	+ 1	+ 1	— 2
<i>a</i> Serpentis	+10	— 3	+ 7	+ 4
<i>a</i> Scorpii	—10	+13	+ 3	+ 0
<i>a</i> Herculis	+ 0	+ 1	+ 1	— 2
<i>a</i> Ophiuchi	+10	— 3	+ 7	+ 4
<i>a</i> Lyræ	+ 0	— 4	— 4	— 7
<i>γ</i> Aquilæ	+10	— 6	+ 4	+ 1
<i>a</i> Aquilæ	—10	+10	+ 0	— 3
<i>β</i> Aquilæ	+10	— 3	+ 7	+ 4
<i>α</i> ² Capricorni	+10	— 6	+ 4	+ 1
<i>a</i> Cygni	—10	— 1	—11	—14
<i>a</i> Aquarii	+10	— 2	+ 8	+ 5
<i>a</i> Piscis Australis	+20	— 6	+14	+11
<i>a</i> Pegasi	+ 0	+ 3	+ 3	+ 0
[<i>v</i>]	+160 — 60	+50 —51	+135 — 36	+79 —76

The accidental errors of the standard catalogue, as indicated by modern observations, are now sufficiently well known to enable us to make a final determination of all the periodic coefficients. In this final discussion, the approximate corrections depending on the Declination, already found, will be applied before the solution of the equations of the form

$$m \sin \alpha + n \cos \alpha = r.$$

The values of *m* and *n* should not differ much from those already found; since the errors depending on the Declination are largely eliminated. Thus, *e.g.*, the error for *a* Canis Majoris is counterbalanced by that for *a* Aurigæ, and the error for *a* Piscis Australis by that for *a* Cygni.

The method of procedure will be the same as before. The residuals given on page 143 and following, are first corrected by the values given in the last column of Table IV. Including *a* Canis Majoris and *a* Piscis Australis, the following are the values of *ε*, to be applied to the observations:—

For Greenwich	$\epsilon = +.028$
Washington, I.	$= +.008$
Oxford	$= +.029$
Paris	$= +.036$
Melbourne	$= +.064$
Edinburgh	$= +.036$
Brussels	$= +.056$
Washington, II.	$= +.057$
Harvard College	$= +.019$

Subtracting the values of ϵ , we have Table V.

Table VI. is formed by subtracting from the residuals in Table V. the provisional corrections depending on the Declination, already obtained. From the residuals of Table VI. are found the following periodic equations of single period:—

For Greenwich	$r = -.007 \sin a + .011 \cos a.$
Washington, I.	$r = -.009 \sin a + .007 \cos a.$
Oxford	$r = -.014 \sin a + .021 \cos a.$
Paris	$r = -.024 \sin a + .021 \cos a.$
Melbourne	$r = -.034 \sin a + .021 \cos a.$
Edinburgh	$r = -.013 \sin a + .016 \cos a.$
Brussels	$r = -.039 \sin a + .022 \cos a.$
Washington, II.	$r = -.042 \sin a + .019 \cos a.$
Harvard College	$r = -.003 \sin a + .002 \cos a.$

Computing the values of r for each star, and subtracting from the residuals in Table VI., we have Table VII.

From the residuals of Table VII., we have the following normal equations for the more accurate determination of a and b :—

	Green- wich.	Wash. I.	Oxford.	Paris.	Mel- bourne.	Brus- sels.	Wash. II.
$3.79 \Delta a + 4.38 \Delta b = \Sigma r'' \sin \delta =$	-19	$+ 6$	-9	-13	$+ 0$	$+20$	-17
$4.38 \Delta a + 28.29 \Delta b = \Sigma r'' \cos \delta =$	-76	$+34$	$+1$	$- 2$	$+21$	$+34$	$+81$
Edinburgh.				Harvard College.			
$2.63 \Delta a + 5.45 \Delta b = \Sigma r'' \sin \delta =$	0	$3.66 \Delta a + 4.86 \Delta b = \Sigma r'' \sin \delta = + 84$					
$5.45 \Delta a + 23.48 \Delta b = \Sigma r'' \cos \delta =$	-88	$4.86 \Delta a + 26.43 \Delta b = \Sigma r'' \cos \delta = +115$					

Whence:

For Greenwich	$\Delta a = -.003$	$\Delta b = -.002$
Washington, I.	$= +.001$	$= +.001$
Oxford	$= -.002$	$= +.000$
Paris	$= -.005$	$= +.001$
Melbourne	$= -.001$	$= +.001$
Edinburgh	$= +.014$	$= -.007$
Brussels	$= +.004$	$= +.001$
Washington, II.	$= -.009$	$= +.004$
Harvard College	$= +.004$	$= +.004$

Subtracting the values of r , computed with these coefficients, from the residuals of Table VII., we have Table VIII.

From the residuals of Table VIII., we have the following normal equations for determining the periodic coefficients for errors of double period:—

	Green- wich.	Wash. I.	Oxford.	Paris.	Mel- bourne.	Brus- sels.	Wash. II.
15.70 m' — .41 $n' = \Sigma r' \sin 2\alpha =$	—19	+39	—74	—22	+32	+42	+79
.41 $m' + 16.28 n' = \Sigma r' \cos 2\alpha =$	+15	—77	+5	+77	+12	+15	+23
Edinburgh.				Harvard College.			
12.64 m' — .61 $n' = \Sigma r' \sin 2\alpha =$	—86		14.75 $m' +$	.28 $n' = \Sigma r' \sin 2\alpha =$	+121		
.61 $m' + 18.33 n' = \Sigma r' \cos 2\alpha =$	—37		.28 $m' + 15.22 n' = \Sigma r' \cos 2\alpha =$	—26			

Whence:

For Greenwich	$m' = -.001$	$n' = +.001$
Washington, I.	$= +.002$	$= -.005$
Oxford	$= -.005$	$= +.000$
Paris	$= -.001$	$= +.005$
Melbourne	$= +.002$	$= +.001$
Edinburgh	$= -.007$	$= -.002$
Brussels	$= +.003$	$= +.001$
Washington, II.	$= +.005$	$= +.001$
Harvard College	$= +.008$	$= -.002$

Subtracting the values of r' , computed with the coefficients m' and n' , from the residuals of Table VIII., we have finally Table IX., containing the final corrections to the assumed places.

TABLE V.

	Green- wich.	Wash- ton, I.	Oxford.	Paris.	Mel- bourne.	Edin- burgh.	Brussels.	Wash- ton, II.	Harv'd College.
α Andromedæ . .	—10	+12	+34	+21	+17	—3	+21	+30	+28
γ Pegasi	+12	+11	+37	+24	+17	—14	+7	+9	—5
α Arietis	+1	+5	—16	+8	+13	—7	+17	+2	+28
α Ceti	—4	—25	—1	—3	—8	+24	—12	+2	+8
α Tauri	—12	+1	—11	—17	—14	—11	—24	—26	+12
α Aurigæ	—18	+10	+8	—26	—53	...	—11	—20	+50
β Orionis	+9	—2	—11	—47	—22	+29	—51	—86	—16
β Tauri	—15	+12	—12	—3	—31	—66	—51	+31	+17
α Orionis	—8	—4	—26	—19	—47	+0	—36	—34	—23
α Canis Majoris .	+2	—8	—28	—45	—33	...	—68	—95	...
α Canis Minoris .	—6	—28	—13	—22	—47	+4	—51	—71	—23
β Geminorum . .	—18	—11	—19	—14	—44	—39	—38	—34	+11
α Hydræ	—17	—20	—22	—50	—40	+45	—56	—56	—31
α Leonis	—13	—18	—7	—32	—50	+29	—33	—55	—2
β Leonis	—23	—18	—21	—16	—10	—37	—27	+7	+8
α Virginis	+5	—17	—36	—20	—23	+37	—2	—36	+9
α Bootis	+0	—0	—28	+9	+6	—26	+7	+9	—5
α^2 Libræ	+0	+1	—17	+17	+18	...	+14	+2	—43
α Coronæ	—6	+9	—11	+24	+26	—43	+4	+51	+19
α Serpentis . . .	+7	+5	—1	—2	+13	+7	+3	+20	+5
α Scorpii	+12	+2	+3	—36	+16	...	+25	—25	+1
α Herculis	—13	+3	+29	+14	+27	—15	+56	+28	+9
α Ophiuchi	—6	+18	+7	+16	+33	+11	+38	+29	—5
α Lyræ	+2	+12	+17	+47	+21	+3	+18	+89	+4
γ Aquilæ	+13	+3	+22	+22	+48	+24	+31	+42	—8
α Aquilæ	+4	+9	+19	+27	+44	+29	+24	+35	+28
β Aquilæ	+6	+4	+13	+30	+43	+12	+47	+32	+15
α^3 Capricorni . .	+12	+21	+14	—1	+10	...	+76	+49	...
α Cygni	+6	+16	+27	+50	+40	+15	+16	+14	+17
α Aquarii	+28	+13	+18	+26	+10	+47	+39	+36	—24
α Piscis Australis	+34	—15	+18	+25	+16	...	+19	+19	—58
α Pegasi	+11	+1	+28	+36	+35	+6	+29	+8	—9
[v]	+166 —169	+168 —166	+294 —280	+379 —370	+435 —440	+293 —290	+480 —467	+542 —540	+253 —268

TABLE VI.

	Green- wich.	Wash- gton, I.	Oxford	Paris.	Mel- bourne.	Edin- burgh.	Bruss- els.	Wash- gton, II.	Harv'd College.
α Andromedæ . .	- 4	+ 9	+ 32	+ 11	+ 18	+ 22	+ 27	+ 18	+ 19
γ Pegasi	+ 12	+ 12	+ 38	+ 22	+ 21	+ 13	+ 12	+ 11	- 2
α Arietis	+ 4	+ 4	- 17	+ 1	+ 16	+ 9	+ 23	- 9	+ 24
α Ceti	- 8	- 21	+ 2	+ 4	- 2	- 5	- 8	+ 15	+ 19
α Tauri	- 12	+ 2	- 11	- 19	- 10	+ 7	- 19	- 27	+ 13
α Aurigæ	- 6	+ 2	+ 2	- 48	- 55	...	- 4	- 49	+ 28
β Orionis	+ 1	+ 5	- 5	- 33	- 15	- 10	- 52	- 62	+ 4
β Tauri	- 9	+ 9	- 14	- 13	- 30	- 41	- 45	+ 19	+ 18
α Orionis	- 10	- 1	- 24	- 15	- 42	- 12	- 31	- 25	- 5
α Canis Majoris .	- 9	+ 1	- 20	- 25	- 25	...	- 64	- 64	...
α Canis Minoris .	- 9	- 25	- 10	- 17	- 42	- 11	- 47	- 61	- 13
β Geminorum . .	- 12	- 14	- 21	- 24	- 43	- 14	- 32	- 46	- 20
α Hydræ	- 25	- 13	- 16	- 36	- 33	+ 6	- 53	- 32	- 11
α Leonis	- 13	- 16	- 6	- 32	- 46	- 32	- 28	- 51	+ 2
β Leonis	- 23	- 17	- 20	- 17	- 6	- 35	- 22	+ 7	+ 11
α Virginis	- 4	- 9	- 30	- 4	- 16	- 6	+ 1	- 8	+ 31
α Bootis	+ 2	+ 0	- 28	+ 5	+ 9	- 16	- 17	+ 5	- 7
α^2 Libræ	- 11	+ 10	- 10	+ 3	- 10	...	+ 17	+ 32	- 18
α Coronæ	+ 0	+ 7	- 13	+ 14	+ 27	- 19	+ 10	+ 39	+ 11
α Serpentis . . .	- 5	+ 8	+ 1	- 2	- 18	- 6	- 8	- 29	+ 4
α Scorpii	- 1	+ 13	+ 13	- 11	+ 24	...	+ 27	+ 14	+ 33
α Herculis	- 13	+ 4	+ 30	+ 13	+ 31	- 14	+ 61	+ 30	+ 12
α Ophiuchi	- 6	+ 20	- 8	- 16	+ 37	+ 8	+ 43	+ 33	- 1
α Lyræ	+ 11	+ 7	+ 13	+ 30	+ 22	+ 45	+ 25	+ 68	- 12
γ Aquilæ	+ 12	+ 5	+ 24	+ 24	+ 52	+ 17	+ 36	+ 48	+ 3
α Aquilæ	+ 2	+ 12	+ 21	+ 30	+ 49	+ 19	+ 29	+ 43	+ 25
β Aquilæ	+ 13	+ 7	+ 16	+ 35	+ 48	- 2	+ 57	+ 42	+ 24
α^2 Capricorni . .	+ 3	+ 29	+ 21	+ 17	- 18	...	+ 79	+ 77	...
α Cygni	+ 17	+ 10	+ 21	+ 29	+ 38	+ 68	+ 23	- 14	- 4
α Aquarii	+ 23	+ 18	+ 22	+ 36	+ 16	- 0	+ 42	+ 53	- 10
α Piscis Australis	+ 20	+ 4	+ 27	+ 52	+ 25	...	+ 16	+ 61	- 24
α Pegasi	+ 11	+ 2	+ 29	+ 35	+ 39	+ 7	+ 34	+ 10	- 6
[v]	+ 136 - 173	+ 196 - 120	+ 320 - 245	+ 379 - 294	+ 508 - 375	+ 206 - 238	+ 570 - 406	+ 654 - 448	+ 278 - 145

TABLE VII.

	Green- wich.	Wash- gton, I.	Oxford	Paris.	Mel- bourne.	Edin- burgh.	Bruss- els.	Wash- gton, II.	Harv'd College.
α Andromedæ . .	- 15	+ 2	+ 11	- 10	- 3	+ 6	+ 5	- 1	+ 17
γ Pegasi	+ 1	+ 5	+ 17	+ 2	+ 1	- 29	- 9	- 7	- 4
α Arietis	- 2	+ 2	- 28	- 5	+ 15	+ 1	+ 24	- 5	+ 24
α Ceti	- 11	- 20	- 3	+ 6	+ 6	+ 3	+ 3	+ 30	+ 20
α Tauri	- 10	+ 7	- 6	- 5	+ 13	- 1	+ 8	+ 5	+ 15
α Aurigæ	- 2	+ 9	+ 11	- 30	- 27	...	+ 29	- 12	+ 31
β Orionis	+ 6	+ 12	+ 4	- 15	+ 13	- 1	- 19	- 25	+ 7
β Tauri	- 4	+ 17	- 4	+ 7	- 1	- 31	- 11	+ 17	+ 11
α Orionis	- 4	+ 8	- 11	+ 8	- 9	- 0	+ 7	+ 56	- 12
α Canis Majoris .	+ 0	+ 11	- 2	+ 3	+ 13	...	- 2	- 19	...
α Canis Minoris .	+ 1	- 14	+ 11	+ 13	- 3	+ 4	+ 12	+ 0	- 7
β Geminorum . .	- 1	- 3	+ 1	+ 7	- 4	+ 4	+ 12	+ 0	- 16
α Hydræ	- 13	- 2	+ 9	- 5	+ 5	+ 12	- 11	+ 10	- 7
α Leonis	+ 1	- 5	+ 19	- 2	- 11	- 12	+ 10	- 13	+ 6
β Leonis	- 11	- 9	+ 2	+ 6	+ 18	- 18	+ 3	+ 29	+ 13
α Virginis	+ 4	- 5	- 15	- 8	- 7	+ 5	+ 9	- 4	+ 32
α Bootis	+ 7	+ 1	- 18	+ 10	+ 9	- 9	- 3	- 2	- 7
α^2 Libræ	- 8	+ 9	- 3	+ 3	- 16	...	+ 9	+ 18	- 18
α Coronæ	+ 1	+ 4	- 11	+ 8	+ 13	- 19	- 8	+ 18	+ 10
α Serpentis . . .	+ 5	+ 5	+ 2	- 5	+ 2	- 8	- 11	+ 6	+ 3
α Scorpii	- 2	+ 8	+ 9	- 24	+ 2	...	+ 1	- 16	+ 31
α Herculis	- 18	- 3	+ 21	- 5	+ 3	- 23	+ 28	- 7	+ 9
α Ophiuchi	- 11	+ 12	- 3	- 5	+ 6	- 3	+ 7	- 6	- 4
α Lyræ	+ 2	- 3	- 4	+ 3	- 15	+ 30	- 17	+ 23	- 15
α Aquilæ	+ 1	- 6	+ 2	- 7	+ 12	- 2	- 8	+ 2	- 6
α Aquilæ	- 9	+ 1	- 1	- 1	+ 9	+ 0	- 16	- 3	+ 31
β Aquilæ	+ 2	- 4	- 7	+ 4	+ 8	- 21	+ 12	- 4	+ 20
α^2 Capricorni . .	- 9	+ 17	- 2	- 14	- 22	...	+ 34	+ 32	...
α Cygni	+ 5	- 1	- 3	- 3	- 2	+ 48	- 21	- 59	- 7
α Aquarii	+ 10	+ 7	- 3	+ 6	- 19	- 20	+ 4	+ 16	- 13
α Piscis Australis	+ 8	- 14	+ 3	+ 25	- 5	...	+ 17	+ 30	- 27
α Pegasi	- 2	- 7	+ 5	+ 9	+ 10	- 12	+ 3	- 19	- 9
[v]	+ 54 - 132	+ 137 - 96	+ 127 - 124	+ 128 - 136	+ 158 - 144	+ 130 - 209	+ 208 - 174	+ 292 - 217	+ 280 - 154

TABLE VIII.

	Green- wich.	Wash'g- ton, I.	Oxford.	Paris.	Mel- bourne.	Edin- burgh.	Bruss'ls.	Wash'g- ton, II.	Harv'd College.
α Andromedæ . .	-12	+1	+10	-9	-4	+5	+2	-1	+11
γ Pegasi	+4	+4	+17	+2	+0	-25	-11	-9	-9
α Arietis	+1	+1	-29	-4	+14	+2	+21	+5	+18
α Ceti	-9	-21	-3	+5	+5	+9	+2	+27	+16
α Tauri	-7	+6	-7	-5	+12	+2	+6	+3	+10
α Aurigæ	+1	+8	+10	-27	-27	...	+25	-9	+25
β Orionis	+8	+11	+4	-17	+12	+8	-19	-30	+4
β Tauri	-1	+16	-5	+8	-2	-32	-14	+57	+5
α Orionis	-2	+7	-11	+8	-10	+5	+5	+13	-17
α Canis Majoris .	+0	+10	-2	+1	+12	...	-21	-26	...
α Canis Minoris .	+3	-15	+11	-12	-4	+13	-3	-18	-13
β Geminorum . .	+2	-4	+0	+8	-5	+3	+9	+0	-22
α Hydræ	-11	-3	+9	-7	+4	+35	+9	+5	-10
α Leonis	+4	-6	+19	-2	-12	-8	+8	-15	+1
β Leonis	-8	-10	+1	+5	+17	-15	+1	+27	+8
α Virginis	+5	-6	-15	+6	-8	+14	+9	-10	+29
α Bootis	+10	+0	-19	+11	+8	-7	-5	-3	-12
α^2 Libræ	-7	+8	-3	+1	-17	...	+9	+12	-21
α Coronæ	+4	+3	-12	+9	+12	-19	-11	+18	+1
α Serpentis . . .	+7	+4	+2	-5	+1	-3	-12	+3	-1
α Scorpil	-1	+7	+9	-27	+1	...	+2	-24	+29
α Herculis	-15	-4	+21	-5	+5	-19	+26	-9	+4
α Ophiuchi	-8	+11	-3	-5	+2	+1	+5	-8	-9
α Lyræ	+6	-4	-5	+5	-16	+27	-20	+25	-21
γ Aquilæ	+4	-7	+2	-7	+11	+3	-10	+0	+11
α Aquilæ	-7	+0	-1	-1	+8	+5	-18	-6	+26
β Aquilæ	+4	-5	-7	+4	+7	-16	+11	-7	+16
α^2 Capricorni . .	-8	+16	-2	-16	-23	...	+34	+26	...
α Cygni	+8	-2	-4	+0	-2	+43	-56	-56	-13
α Aquarii	+12	+6	-3	+5	-20	-13	+3	+12	-17
α Piscis Australis	+8	-14	+4	+21	-7	...	-16	+23	-28
α Pegasi	+1	-8	+5	+9	+9	-8	+1	-21	-14
[v]	+92 -96	+119 -109	+124 -131	+120 -137	+140 -157	+175 -165	+179 -194	+249 -257	+206 -218

TABLE IX.

α Andromedæ . .	-13	+6	+10	-14	-5	+7	+1	-2	+13
γ Pegasi	+3	+9	+17	-3	-1	-23	+12	-10	-7
α Arietis	+1	+1	-25	-5	+11	+9	+18	-9	+12
α Ceti	-8	-23	+2	+6	+3	+16	-1	+22	+8
α Tauri	-5	+2	-3	-1	+12	+6	+5	+0	+3
α Aurigæ	+2	+2	+12	-23	-27	...	+25	-10	+19
β Orionis	+9	+5	+6	-12	+12	+9	-19	-31	-2
β Tauri	+0	+10	-3	+13	-2	-31	-14	+56	+0
α Orionis	-1	+2	-10	+13	-9	+4	+6	+13	-20
α Canis Majoris .	+1	+6	-4	+6	+14	...	-19	-23	...
α Canis Minoris .	+3	-17	+7	+14	-2	+7	+0	-13	-8
β Geminorum . .	+2	-5	-4	+10	-2	+3	+12	+5	-17
α Hydræ	-12	+0	+4	-9	+6	+28	-6	+10	-9
α Leonis	+2	-2	+15	-5	-11	-13	+10	-12	+9
β Leonis	-9	-5	+0	+0	+16	-14	+0	+27	+11
α Virginis	+5	-3	-12	+3	-10	+20	+7	-14	+26
α Bootis	+11	+0	-15	+10	+6	+0	-8	-7	+18
α^2 Libræ	-6	+7	+2	-1	-19	...	+6	+7	-29
α Coronæ	+5	+0	-7	+11	+10	-13	-14	+13	-4
α Serpentis . . .	+8	+0	+7	-2	+1	+3	-15	-2	-10
α Scorpil	+1	+2	+13	-23	+0	...	+1	-27	+22
α Herculis	-14	-10	+23	-1	+2	-18	+26	-10	-2
α Ophiuchi	-7	+5	-2	+0	+5	+1	+5	-8	-13
α Lyræ	+7	-8	-6	-10	-14	+23	-18	+27	-21
γ Aquilæ	+4	-8	-2	-5	+14	-3	-7	+5	-6
α Aquilæ	-7	-1	-5	+1	+11	-1	-15	-1	+31
β Aquilæ	+4	-6	-11	+6	+10	-23	+14	-2	+21
α^2 Capricorni . .	-9	+16	-7	-15	-21	...	+37	+31	...
α Cygni	+7	-1	-9	+0	+0	+36	-22	-51	-5
α Aquarii	+11	+10	-8	+2	-18	-18	+5	+16	-8
α Piscis Australis	+6	-9	+1	+16	-7	...	+15	+23	-21
α Pegasi	-1	-3	+3	+3	+9	-10	+2	-19	-8
[v]	+92 -92	+83 -101	+122 -133	+125 -118	+141 -149	+169 -170	+180 -185	+255 -251	+175 -201

SYSTEM OF WEIGHTS.

	$[vv]$	w'	w''	w
For Greenwich	1432	10.0	10.0	10
Washington, I.	1962	7.3	8.3	8
Oxford	3201	4.5	9.2	7
Paris	3137	4.6	8.3	6
Melbourne	4010	3.5	7.2	5
Edinburgh	8493	1.7	8.9	5
Brussels	6527	2.2	8.3	5
Washington, II.	13358	1.1	5.6	3
Harvard College	7302	2.0	3.0	2

With the weights w we have finally :—

TABLE X.

	Assumed correction to Newcomb.	Derived correction to assumed R. A.	Final correction to Newcomb.
α Andromedæ	— 3	+ 1	— 2
γ Pegasi	— 6	+ 0	— 6
α Arietis	— 3	+ 0	— 3
α Ceti	— 3	+ 1	— 2
α Tauri	+ 1	— 1	+ 0
α Aurigæ	— 21	+ 0	— 21
β Orionis	+ 13	+ 0	+ 13
β Tauri	+ 6	— 2	+ 4
α Orionis	+ 6	+ 0	+ 6
α Canis Majoris	+ 7	+ 1	+ 8
α Canis Minoris	+ 6	+ 0	+ 6
β Geminorum	— 2	— 1	— 3
α Hydræ	— 2	+ 0	— 2
α Leonis	— 3	+ 0	— 3
β Leonis	— 3	+ 0	— 3
α Virginis	— 2	— 1	— 3
α Bootis	+ 4	+ 0	+ 4
α^2 Libræ	+ 6	+ 2	+ 8
α Coronæ	— 2	+ 0	— 2
α Serpentis	+ 4	+ 0	+ 4
α Scorpii	+ 0	+ 1	+ 1
α Herculis	— 2	+ 1	— 1
α Ophiuchi	+ 4	+ 1	+ 5
α Lyræ	— 7	— 1	— 8
γ Aquilæ	+ 1	+ 1	+ 2
α Aquilæ	— 3	+ 1	— 2
β Aquilæ	+ 4	+ 0	+ 4
α^2 Capricorni	+ 1	— 2	— 1
α Cygni	— 14	+ 2	— 12
α Aquarii	+ 5	— 1	+ 4
α Piscis Australis	+ 11	+ 0	+ 11
α Pegasi	+ 0	+ 1	+ 1
$[v]$	+ 79 — 76	+ 13 — 9	+ 81 — 74

In the following table will be found the predicted seconds of Right Ascension for every five years from 1870 to 1900:—

TABLE XI.

	1870.	1875.	1880.	1885.	1890.	1895.	1900.
<i>α</i> Andromedæ .	<i>s.</i> 40.321	<i>s.</i> 55.762	<i>s.</i> 11.208	<i>s.</i> 26.659	<i>s.</i> 42.114	<i>s.</i> 57.573	<i>s.</i> 13.038
<i>γ</i> Pegasi	32.626	48.036	3.449	18.864	34.282	49.702	5.125
<i>α</i> Arietis	50.963	7.800	24.643	41.491	58.344	15.203	32.066
<i>α</i> Ceti	29.148	44.792	0.438	16.086	31.737	47.391	3.047
<i>α</i> Tauri	27.785	44.963	2.144	19.327	36.514	53.702	10.894
<i>α</i> Aurigæ	5.805	27.415	49.529	11.647	33.769	55.895	18.024
<i>β</i> Orionis	17.472	31.875	46.280	0.685	15.091	29.498	43.906
<i>β</i> Tauri	4.530	23.469	42.411	1.354	20.300	39.247	58.197
<i>α</i> Orionis	8.056	24.288	40.522	56.756	12.991	29.226	45.463
<i>α</i> Canis Majoris	25.042	38.284	51.551	4.847	18.178	31.401	44.504
<i>α</i> Canis Minoris	29.703	45.400	1.138	16.904	32.673	48.414	4.113
<i>β</i> Geminorum .	21.484	39.891	58.295	16.696	35.094	53.488	11.879
<i>α</i> Hydræ	11.938	26.685	41.431	56.177	10.923	25.668	40.414
<i>α</i> Leonis	26.795	42.807	58.815	14.822	30.826	46.827	2.826
<i>β</i> Leonis	25.634	40.960	56.285	11.607	26.928	42.247	57.564
<i>α</i> Virginis	20.811	36.570	52.331	8.096	23.863	39.634	55.407
<i>α</i> Bootis	43.964	57.637	11.310	24.984	38.658	52.333	6.009
<i>α</i> ² Libræ	41.409	57.943	14.482	31.024	47.570	4.121	20.675
<i>α</i> Coronæ	11.072	23.766	36.461	49.157	1.853	14.550	27.247
<i>α</i> Serpentis . . .	51.970	6.723	21.477	36.233	50.991	5.750	20.510
<i>α</i> Scorpii	26.392	44.731	3.073	21.418	39.768	58.121	16.478
<i>α</i> Herculis	43.241	56.905	10.571	24.237	37.904	51.572	5.241
<i>α</i> Ophiuchi . . .	54.054	7.965	21.877	35.790	49.704	3.619	17.535
<i>α</i> Lyræ	32.233	42.389	52.545	2.701	12.857	23.014	33.171
<i>γ</i> Aquilæ	4.765	19.027	33.289	47.550	1.812	16.073	30.333
<i>α</i> Aquilæ	26.428	41.068	55.708	10.347	24.985	39.623	54.260
<i>β</i> Aquilæ	55.662	10.398	25.135	39.870	54.606	9.341	24.076
<i>α</i> ² Capricorni . .	50.420	7.089	23.755	40.419	57.081	13.741	30.399
<i>α</i> Cygni	0.044	10.264	20.484	30.705	40.927	51.149	1.371
<i>α</i> Aquarii	6.389	21.806	37.222	52.637	8.052	23.465	38.877
<i>α</i> Piscis Australis	27.756	44.398	1.035	17.667	34.293	50.914	7.529
<i>α</i> Pegasi	17.207	32.127	47.049	1.972	16.896	31.822	46.749

In Tables XII, XIII, and XIV. will be found the corrections necessary to reduce the observations made at different observatories to a homogeneous system.

Let

C = the correction to be applied to the observations.

Then

$$C = \varepsilon + (m \sin a + n \cos a) + (m' \sin 2a + n' \cos 2a) + (a \sin \delta + b \cos \delta).$$

Thus for Edinburgh, when $a = 6^\circ$ and $\delta = -20^\circ$:—

$$C = +.036 \quad -.013 \quad +.002 \quad +.046 = +.071.$$

TABLE XII.

Tabular Corrections for Errors of Single Period.

R. A.	Green- wich.	Washing- ton, D.	Oxford.	Paris.	Mel- bourne.	Edin- burgh.	Brussels.	Washing- ton, D.	Harvard College.
<i>h.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>
0	+.011	+.007	+.021	+.021	+.021	+.016	+.022	+.019	+.002
1	+.009	+.005	+.016	+.014	+.011	+.013	+.011	+.007	+.001
2	+.006	+.002	+.011	+.006	+.001	+.008	+.000	-.005	+.001
3	+.003	-.001	+.005	-.002	-.009	+.002	-.012	-.017	-.001
4	+.000	-.004	-.002	-.011	-.020	-.003	-.023	-.028	-.002
5	-.004	-.007	-.009	-.018	-.028	-.009	-.032	-.036	-.002
6	-.007	-.009	-.014	-.024	-.034	-.013	-.039	-.042	-.003
7	-.010	-.011	-.019	-.028	-.038	-.017	-.044	-.046	-.004
8	-.012	-.012	-.022	-.031	-.040	-.019	-.045	-.046	-.004
9	-.013	-.011	-.025	-.032	-.039	-.020	-.044	-.043	-.003
10	-.013	-.010	-.025	-.030	-.035	-.020	-.038	-.037	-.003
11	-.013	-.009	-.024	-.026	-.029	-.019	-.031	-.029	-.003
12	-.011	-.007	-.021	-.021	-.021	-.016	-.022	-.019	-.002
13	-.009	-.005	-.016	-.014	-.011	-.013	-.011	-.007	-.001
14	-.006	-.002	-.011	-.006	-.001	-.008	+.000	+.005	-.001
15	-.003	+.001	-.005	+.002	+.009	-.002	+.012	+.017	+.001
16	-.000	+.004	+.002	+.011	+.020	+.003	+.023	+.028	+.002
17	+.004	+.007	+.009	+.018	+.028	+.009	+.032	+.036	+.002
18	+.007	+.009	+.014	+.024	+.034	+.013	+.039	+.042	+.003
19	+.010	+.011	+.019	+.028	+.038	+.017	+.044	+.046	+.004
20	+.012	+.012	+.022	+.031	+.040	+.019	+.045	+.046	+.004
21	+.013	+.011	+.025	+.032	+.039	+.020	+.044	+.043	+.003
22	+.013	+.010	+.025	+.030	+.035	+.020	+.038	+.037	+.003
23	+.013	+.009	+.024	+.026	+.029	+.019	+.031	+.029	+.003

TABLE XIII.

Tabular Corrections for Errors of Double Period.

R. A.	Green- wich.	Washing- ton, I.	Oxford.	Paris.	Mel- bourne.	Edin- burgh.	Brussels.	Washing- ton, II.	Harvard College.
<i>h.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>
0	+0.001	-0.005	+0.000	+0.005	+0.001	-0.002	+0.001	+0.001	-0.002
1	+0.000	-0.003	-0.002	+0.003	+0.002	-0.005	+0.003	+0.003	+0.002
2	+0.000	+0.000	-0.004	+0.001	+0.003	-0.007	+0.004	+0.005	+0.006
3	-0.001	+0.002	-0.005	-0.001	+0.002	-0.007	+0.003	+0.005	+0.008
4	-0.002	+0.004	-0.004	-0.003	+0.001	-0.005	+0.002	+0.003	+0.008
5	-0.002	+0.005	-0.002	-0.005	+0.000	-0.001	+0.001	+0.001	+0.006
6	-0.001	+0.005	-0.000	-0.005	-0.001	+0.002	-0.001	-0.001	+0.002
7	+0.000	+0.003	+0.002	-0.003	-0.002	+0.005	-0.003	-0.003	-0.002
8	+0.000	+0.000	+0.004	-0.001	-0.003	+0.007	-0.004	-0.005	-0.006
9	+0.001	-0.002	+0.005	+0.001	-0.002	+0.007	-0.003	-0.005	-0.008
10	+0.002	-0.004	+0.004	+0.003	-0.001	+0.005	-0.002	-0.003	-0.008
11	+0.002	-0.005	+0.002	+0.005	+0.000	+0.001	-0.001	-0.001	-0.006
12	+0.001	-0.005	+0.000	+0.005	+0.001	-0.002	+0.001	+0.001	-0.002
13	+0.000	-0.003	-0.002	+0.003	+0.002	-0.005	+0.003	+0.003	+0.002
14	+0.000	+0.000	-0.004	+0.002	+0.003	-0.007	+0.004	+0.005	+0.006
15	+0.001	+0.002	-0.005	+0.001	+0.002	-0.007	+0.003	+0.005	+0.008
16	-0.002	+0.004	-0.004	-0.003	+0.001	-0.005	+0.002	+0.003	+0.008
17	-0.002	+0.005	-0.002	-0.005	+0.000	-0.001	+0.001	-0.001	+0.006
18	-0.001	+0.005	+0.000	-0.005	-0.001	+0.002	-0.001	-0.001	+0.002
19	+0.000	+0.003	+0.002	-0.003	-0.002	+0.005	-0.003	-0.003	-0.002
20	+0.000	+0.000	+0.004	-0.001	-0.003	+0.007	-0.004	-0.005	-0.006
21	+0.001	-0.002	+0.005	+0.001	-0.002	+0.007	-0.003	-0.005	-0.008
22	+0.002	-0.004	+0.004	+0.003	-0.001	+0.005	-0.002	-0.003	-0.008
23	+0.002	-0.005	+0.002	+0.005	+0.000	+0.001	-0.001	-0.001	-0.006

TABLE XIV.

Tabular Corrections depending on the Declination.

<i>δ</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>	<i>s.</i>
-30°	+0.015	-0.012	-0.009	-0.024	-0.009	+0.059	-0.002	-0.033	-0.033
-20	+0.011	-0.009	-0.008	-0.019	-0.008	+0.046	-0.002	-0.027	-0.025
-10	+0.007	-0.007	-0.006	-0.014	-0.007	+0.033	-0.003	-0.020	-0.018
+ 0	+0.003	-0.004	-0.004	-0.008	-0.005	+0.018	-0.003	-0.012	-0.010
+10	-0.001	-0.001	-0.002	-0.002	-0.003	+0.003	-0.003	-0.004	-0.002
+20	-0.005	+0.001	+0.000	+0.003	-0.001	-0.012	-0.003	+0.005	+0.007
+30	-0.009	+0.004	+0.001	+0.010	+0.001	-0.027	-0.004	+0.013	+0.015
+40	-0.013	+0.007	+0.004	+0.016	+0.003	-0.042	-0.003	+0.021	+0.023
+50	-0.016	+0.009	+0.006	+0.021	+0.005	-0.055	-0.003	+0.028	+0.031
+60	-0.020	+0.011	+0.008	+0.025	+0.006	-0.067	-0.002	+0.034	+0.037
+70	-0.022	+0.013	+0.009	+0.029	+0.007	-0.076	-0.002	+0.040	+0.042
+80	-0.023	+0.015	+0.010	+0.032	+0.009	-0.083	-0.002	+0.045	+0.046
+90	-0.024	+0.016	+0.011	+0.034	+0.010	-0.087	-0.001	+0.047	+0.048

PART II.

IN seeking for an explanation of the origin of periodic errors in observed Right Ascensions, the following facts, drawn from the preceding discussion, will not escape attention:—

I. That for the observatories under consideration, the coefficients of $\sin \alpha$, and also of $\cos \alpha$, have the same sign, varying only in magnitude.

II. That for each observatory the maximum of negative errors occurs at about 6 hours of Right Ascension, the maximum of positive errors at about 18 hours, the zero of error varying but little from 3 hours.

III. That the periodic error depending on the Declination, is zero at about 12° north.

There seems to be only one circumstance that can vitiate these conclusions, viz., that the derived standard catalogue is itself subject to the errors in question. In order to remove doubt on this point as far as possible, I give in Tables I. and II. a comparison of the standard Right Ascensions with the following authorities, viz.: Maskelyne, from 1765 to 1807; Struve, 1825; Struve, 1830; Argelander, 1830; Pulkowa, 1845; and Newcomb, 1870. These authorities are selected because there is good reason to suppose that the observations are in a great measure free from errors of single period. Certainly no more severe test than this can well be applied; for the standard catalogue has been formed quite independently of them. If it is found that the Right Ascensions derived from this discussion of only modern observations, satisfy observations distributed over a range of nearly 100 years, they must be accepted as quite near the truth. If the comparison indicates no periodic errors of greater magnitude than the probable errors of observation, then the standard catalogue must also be regarded as quite nearly free from these errors.

Instead of using the various catalogues constructed from Maskelyne's observations, I give in Table I., in hundredths of seconds, the comparison for each year, the data being derived from the Ledger of Stars, prepared with great care by the Rev. Robert Main. The final Right Ascensions given by Mr. Main are corrected for quite a large number of errors found in Maskelyne's original computations. This direct comparison will also enable us to form an estimate of the relative value of the individual observations. Argelander's places of α Canis Majoris and α Canis Minoris have been corrected by $+.04^s$ and $-.04^s$ respectively, on account of change of position between 1826 and 1830. Struve's positions for 1830 have been corrected by $+.05^s$ and $-.05^s$ respectively. From the direct residuals have been subtracted the values of r'' derived from the following equations:—

Struve	1825, $r'' = +.036 \sin \delta$	$-.007 \cos \delta$.
Struve	1830, $= +.074 \sin \delta$	$-.015 \cos \delta$.
Argelander	1830, $= -.028 \sin \delta$	$+.005 \cos \delta$.
Pulkowa	1845, $= -.023 \sin \delta$	$+.004 \cos \delta$.
Newcomb	1870, $= +.014 \sin \delta$	$-.002 \cos \delta$.

TABLE I. — Comparison with Maskelyne's Observations.

Year . . . ε . . .	1765 ¹ . +33.	1765 ² . +07.	1766 +29.	1767. +04.	1768. +12.	1769. +00.	1770. +09.	1771. +03.	1772. +03.
α Andromedæ . .	-15	-16	-3	-1	-3	-3	-7	+3	-22
γ Pegasi	-13	-15	-3	+4	-4	-6	-6	-2	-11
α Arietis	-8	+0	-5	-4	-13	-5	-11	+4	-6
α Ceti	-15	+9	-7	+12	-10	-1	-10	...	...
α Tauri	-3	+2	-7	+3	+8	+0	+4	-7	+3
α Aurigæ	+26	+19	...	...	...	...	...	...	...
β Orionis	-15	-11	+(20)	+13	+5	-8	-3	-3	+6
β Tauri	+11	+4	...	-4	...	-(36)	-5	...	...
α Orionis	+3	+2	+4	+0	+10	-3	+6	+2	-4
α Canis Majoris .	+12	+8	+5	+5	+(52)	-(49)	...	...	...
α Canis Minoris .	-4	-11	-2	-1	-1	-5	-6	-4	+5
β Geminorum . .	+4	+2	+17	+1	+7	+8	+5	+7	+3
α Hydræ	-13	-13	-8	-13	-14	-7	-18	...	...
α Leonis	+6	+0	+7	+2	+9	+12	-2	+2	+0
β Leonis	+18	+14	+4	+2	+1	-3	+6	+9	+22
α Virginis	+16	+28	+4	+7	+8	-1	+16	+17	+11
α Bootis	+4	+1	+5	-7	-1	-1	+2	+1	-4
α ² Libræ	+18	+17	+2	-15	+18	+(16)	+26	...	...
α Coronæ	+0	+12	+7	-12	+11	-6	+8	-1	-3
α Serpentis . . .	+3	+11	+6	-6	+2	+3	+4	+2	+4
α Scorpii	-6	+0	-9	-13	+12	-2	-6	-7	-1
α Herculis	+42	+5	+(41)	...	+(35)	...	...	...	...
α Ophiuchi	-2	-5	-5	-1	-8	+2	+0	+1	-4
α Lyræ	-4	-3	-20	+6	+(25)	...	+(21)	...	...
γ Aquilæ	-3	+1	+5	+4	-5	+13	+9	...	...
α Aquilæ	-8	-5	-1	-1	-9	+3	+6	+0	+0
β Aquilæ	-8	-2	-1	-1	+2	+4	+7	...	...
α ² Capricorni . .	-3	-19	+0	+9	-4	+3	+3	+3	+4
α Cygni	-11	-12	+9	+1	+6	...	-5	...	...
α Aquarii	-1	-1	-2	-5	-4	+2	-1	-5	+0
α Piscis Australis	-6	+2	+3	+15	+(26)	...	...	...	...
α Pegasi	-27	-26	-1	+7	-10	+4	-1	-2	-10
[v]	+1.63 -1.65	+1.37 -1.39	+0.69 -0.83	+0.89 -0.86	+1.00 -0.91	+0.55 -0.50	+0.96 -0.87	+0.42 -0.40	+0.58 -0.65

TABLE I. (continued).

Year . . . ε . . .	1779. +03.	1780. +02.	1781. -02.	1782. +03.	1783. +00.	1784. +01.	1785. +00.	1796. +32.	1797. +34.
α Andromedæ . .	+7	+0	-6	-8	-4	-8	-2	+1	+6
γ Pegasi	-1	-6	-1	-4	-7	-4	-4	+0	+5
α Arietis	-4	+8	+9	-1	-10	-4	+2	+2	+5
α Ceti	-8	+3	+12	+1	-3	+2	-5	+10	+3
α Tauri	+4	+3	-9	-2	-7	-6	+2	+4	+7
α Aurigæ . . . . .	...	...	+7	-18	-11	+8	+4	+4	-2
β Orionis	-3	-2	-3	+1	+0	+1	+3	-9	+0
β Tauri	+11	+5	+2	-7	-4	-3	-8	+3	+2
α Orionis	+8	-8	-2	+1	-4	-1	+0	-2	+5
α Canis Majoris .	+(17)	-3	-(23)	-8	-1	+1	+1	-11	+3
α Canis Minoris .	-(17)	+3	-7	+5	+4	+1	+4	+9	+3
β Geminorum . .	...	+2	-10	-(63)	-2	-3	-2	+15	-1
α Hydræ	-(27)	-(19)	-7	+4	+0	-6	+3	-8	-8
α Leonis	-3	-2	+10	+3	-4	+5	+12	-6	+1
β Leonis	+4	+14	+3	+5	+1	+18	+3	-8	-7
α Virginis	-14	+5	-3	+8	+8	+3	+2	-8	-4
α Bootis	+11	-4	-10	+0	+4	-6	-5	-4	-2
α ² Libræ	-13	-7	-5	+5	+15	+2	+2	+1	-14
α Coronæ	+3	-8	-8	+2	+1	-4	-8	+0	-9
α Serpentis . . .	-6	-6	-8	+5	+2	+3	-4	-3	-4
α Scorpii . . . . .	...	+1	-6	-6	-1	+5	+1	-18	-13
α Herculis	+7	-8	...	-2	+5	+0	-8	-1	+1
α Ophiuchi	-8	-7	+4	-1	+3	-1	+2	+1	-3
α Lyræ	+19	-3	-4	-2	-6	-3	-3	+5	+0
γ Aquilæ	+9	+4	+13	+7	+10	+10	+10	+11	+5
α Aquilæ	+0	+0	+4	+1	+2	+1	+2	+4	+3
β Aquilæ	-5	-5	+2	-1	+1	+0	-5	+3	+0
α ² Capricorni . .	-13	-5	+4	-3	+4	+6	+2	-6	-5
α Cygni	+19	...	+9	+4	+1	-10	+2	+6	+1
α Aquarii	-18	+2	-3	+5	+4	+5	-4	+6	+6
α Piscis Australis	-19	+23	+15	+11	+3	-(19)	+6	-9	-1
α Pegasi	+2	-7	+1	+4	-1	+3	+0	+0	+8
[v]	+1.04 -1.15	+0.71 -0.83	+0.98 -0.89	+0.67 -0.68	+0.68 +0.65	+0.71 -0.62	+0.62 -0.58	+0.85 -0.93	+0.64 -0.73

TABLE I. (continued).

Year ε	1798. +39.	1799. +36.	1800. +37.	1801. +34.	1804. +13.	1805. +18.	1806. +14.	1807. +16.
α Andromedæ	+ 6	+ 8	+ 5	+ 0	- 11	+ 2	+ 1	+ 1
γ Pegasi	+ 9	+ 4	+ 5	+ 5	- 1	+ 1	+ 3	+ 2
α Arietis	+ 12	+ 2	+ 10	- 1	- 6	+ 5	- 5	+ 1
α Ceti	+ 6	+ 10	+ 7	- 1	+ 7	+ 3	+ 9	+ 11
α Tauri	- 5	- 9	+ 5	- 7	-(14)	+ 2	+ 18	- 6
α Aurigæ	- 8	- 15	+ 10	- 27	- 20	- 4	+ 3	+ 1
β Orionis	+ 3	- 14	- 3	- 16	+ 11	+ 7	+ 9	+ 1
β Tauri	- 2	- 6	+ 4	- 14	+ 9	- 3	- 4	- 10
α Orionis	+ 3	- 13	- 4	- 14	-(20)	+ 4	- 4	- 1
α Canis Majoris	- 5	- 1	- 10	- 12	+ 3	+ 7	- 7	+ 3
α Canis Minoris	+ 9	- 3	- 6	+ 7	+ 5	+ 0	- 6	- 6
β Geminorum	+ 4	+ 3	- 1	+ 4	- 5	- 2	- 10	- 8
α Hydræ	- 4	- 9	- 17	- 12	-(13)	- 4	- (19)	...
α Leonis	- 3	- 2	- 18	+ 13	-(15)	- 1	+ (15)	+ 8
β Leonis	- 3	+ 8	+ 1	+ 23	+ 1	- 11	- 10	+ 0
α Virginis	- 8	- 5	+ 3	- 9	+ 11	- (28)	- 6	+ 5
α Bootis	- 1	+ 8	+ 3	- 14	- 12	- 1	- 4	-(17)
α ² Libræ . . . . .	...	-(28)	...	-(29)	...	...	...	- 1
α Coronæ	- 5	+ 10	+ 2	- 3	- 10	+ 0	- 2	- 7
α Serpentis	- 2	+ 0	+ 0	+ 3	+ 3	+ 0	+ 11	- 3
α Scorpii	- 18	- 9	- 18	+ 1	+ 7	-(22)	...	+ 7
α Herculis	- 4	- 1	+ 4	- 8	- 8	+ 0	+ 1	- 5
α Ophiuchi	- 1	- 2	+ 2	+ 4	- 4	+ 2	+ 10	- 3
α Lyræ	- 1	+ 7	+ 5	- 7	- 2	- 9	- 9	- 3
γ Aquilæ	+ 2	+ 14	+ 13	+ 21	- 1	- 2	+ 3	+ 3
α Aquilæ	- 2	+ 2	+ 3	+ 7	+ 3	- 2	+ 3	+ 2
β Aquilæ	- 3	+ 0	+ 1	+ 7	+ 2	- 1	+ 3	- 1
α ² Capricorni	- 5	- 7	- 7	- 5	+ 2	+ 0	- 3	- 4
α Cygni	- 4	+ 0	+ 9	- 14	+ 18	- 6	- 8	- 2
α Aquarii	+ 2	+ 5	+ 4	+ 3	+ 9	+ 3	+ 4	- 1
α Piscis Australis	+ 3	- 2	- 9	+ 11	-(21)	+ 4	+ 4	+ 9
α Pegasi	+ 13	+ 10	+ 10	+ 5	- 5	+ 4	+ 2	+ 6
[v]	+72 -84	+91 -98	+106 -93	+133 -145	+91 -85	+44 -46	+84 -78	+62 -61

TABLE II.

	Mask- elyne. 1765- 1772.	Mask- elyne. 1779- 1785.	Mask- elyne. 1796- 1807.	Struve 1825.	Struve 1830.	Arge- lander. 1830.	Pul- kowa. 1845.	New- comb. 1870.	Mean.
α Andromedæ	- 74	- 30	+ 19	+ 51	+ 45	- 10	+ 4	- 6	+ 17
γ Pegasi	- 62	- 39	+ 33	- 9	- 38	- 26	- 4	- 6	- 17
α Arietis	- 53	+ 0	- 25	- 18	- 29	- 2	- 17	- 8	- 15
α Ceti	- 31	+ 3	- 65	- 1	- 4	- 1	- 6	- 17	- 6
α Tauri	+ 3	- 21	+ 10	+ 24	+ 18	+ 5	+ 26	- 1	+ 14
α Aurigæ	+(225)	- 20	- 58	- 18	+ 13	+ 18	- 1	+ 18	+ 6
β Orionis	- 20	- 4	- 11	- 33	- 19	+ 23	- 3	+ 17	+ 3
β Tauri	+ 15	- 6	- 21	+ 22	+ 8	+ 0	+ 7	+ 24	+ 12
α Orionis	+ 22	- 9	- 29	+ 20	+ 20	- 9	+ 20	+ 6	+ 11
α Canis Majoris	+ 50	- 20	- 30	+ 12	+ 20	+ 9	+ 14	+ 4	+ 10
α Canis Minoris	- 30	+ 17	+ 12	+ 5	- 3	+ 20	- 20	+ 8	+ 2
β Geminorum	+ 60	- 38	- 1	+ 8	+ 2	+ 0	- 2	+ 1	+ 2
α Hydræ	- 123	- 12	- 89	- 17	+ 0	- 17	- 16	+ 8	- 8
α Leonis	+ 40	+ 30	- 10	+ 4	+ 4	+ 3	+ 2	- 4	+ 2
β Leonis	+ 48	+ 67	- 6	- 4	- 11	- 5	- 10	- 6	- 7
α Virginis	+ 118	+ 4	- 3	+ 18	+ 23	- 8	- 28	- 14	+ 2
α Bootis	- 4	- 14	+ 1	+ 7	+ 3	+ 7	- 4	+ 8	+ 4
α ² Libræ	+ 110	- 1	- 47	+ 44	+ 48	+ 0	+ 16	+ 21	+ 26
α Coronæ	+ 18	- 31	- 24	- 40	- 36	- 9	+ 8	+ 6	- 14
α Serpentis	+ 32	- 20	+ 5	- 33	- 39	- 10	+ 6	+ 6	- 14
α Scorpii	- 36	- 10	- 74	- 3	+ 1	+ 15	- 2	- 9	+ 0
α Herculis	+ 50	- 10	- 21	- 39	- 38	- 16	+ 23	- 1	- 14
α Ophiuchi	- 24	- 11	+ 6	- 31	- 16	- 7	+ 30	+ 6	- 4
α Lyræ	- 52	- 3	+ 0	+ 19	+ 21	+ 5	- 16	- 15	+ 3
γ Aquilæ	+ 34	+ 90	+ 69	- 9	- 23	- 8	- 6	- 6	+ 10
α Aquilæ	- 30	+ 11	+ 23	+ 5	- 1	- 9	- 10	- 10	- 5
β Aquilæ	+ 1	- 19	+ 11	+ 2	+ 3	+ 0	+ 4	+ 6	+ 3
α ² Capricorni	- 4	- 7	- 40	- 22	- 13	+ 11	- 13	+ 7	- 6
α Cygni	- 20	+ 28	+ 0	+ 3	+ 33	+ 19	- 20	- 13	+ 4
α Aquarii	- 18	- 4	+ 41	+ 10	+ 11	+ 16	+ 0	- 8	+ 6
α Piscis Australis	+ 35	+ 43	- 13	...	...	...	...	- 8	- 8
α Pegasi	- 73	+ 3	+ 55	+ 26	+ 22	- 6	+ 15	- 12	+ 9
[v]	+636 +654	+296 -329	+375 -472	+280 -277	+295 -270	+151 -143	+175 -178	+142 -148	+131 -133

It is apparent from the residuals of Table II. that the standard catalogue, depending wholly on modern observations, is for the most part free both from accidental and periodic errors.

We must therefore conclude, *that if the periodicity is inherent in the observations themselves, it must be produced by a cause common to all instruments and all observers.* It would be difficult to assign any physical cause for the fact, that the zero point of errors depending on the Right Ascension varies but little from 3^h , and on the Declination but little from $+12^\circ$, for all observers and all instruments. No explanation of this periodicity is sufficient which does not account for these observed facts. It is a less violent supposition that the errors in question have been entirely transferred from the provisional Right Ascensions on which the clock errors depend. Professor Newcomb has shown, theoretically, that the errors of single period are eliminated in successive revisions by about 1-5th of their entire amount. The errors are simply differently distributed by applying to the standard catalogue the corrections given by observations, but without changing the zero points. I shall now attempt to show why they can never be wholly eliminated by the present method of observation. I begin by comparing with the standard catalogue, the provisional catalogues on which the clock errors depend, for the observatories under consideration. Greenwich, Oxford, and Edinburgh, employ the same star places for clock errors, the places being communicated each year from Greenwich to Oxford and Edinburgh. The Paris observations depend on Leverrier's places of the fundamental stars, together with a large number of additional stars whose places are given by the observations themselves. Washington II. depends wholly on the places of the British Nautical Almanac for 1860. Brussels depends also mainly on the Nautical Almanac. Melbourne depends on the same authority, plus corrections given by the Melbourne observations. Washington I., from 1862 to 1867, depends on the places of the American Ephemeris. From 1867 to 1869, the clock errors depend on the same authority, plus corrections given by the observations from 1862 to 1865. For 1870 they depend on Newcomb's catalogue, found in the volume for 1867. Harvard College depends on the "Pulkowa Hauptsterne." The residuals are given in the following table:—

TABLE III.

	Greenw. Oxford, Edinb.	Lever- rier.	Amer. Ephem.	Amer. Ephem. + Wash. Corr.	New- comb.	Mel- bourne.	Brus- sels.	Naut. Alm'nac	Pul- kowa.
Year . . . ε . . .	1865. + 19	1860. + 39	1867. + 14	1867. + 13	1870. - 22	1865. + 53	1865. + 62	1865. + 67	1871. + 18
α Andromedæ . . .	- 9	+ 1	+ 16	+ 17	- 1	+ 6	+ 14	+ 9	+ 14
γ Pegasi . . .	+ 1	+ 5	- 4	+ 17	- 5	+ 18	+ 12	+ 7	- 4
α Arietis . . .	+ 11	- 19	- 4	- 13	- 5	+ 9	- 17	- 22	+ 3
α Ceti . . .	+ 21	+ 27	- 4	- 23	- 18	+ 13	+ 41	+ 36	+ 9
α Tauri . . .	- 9	- 54	- 14	- 13	+ 1	- 21	- 61	- 65	- 8
α Aurigæ . . .	...	- 37	- 44	...	+ 27	...	- 94	- 99	- 51
β Orionis . . .	+ 21	+ 0	+ 6	- 3	+ 13	- 25	- 84	- 9	- 15
β Tauri . . .	- 39	- 17	+ 6	+ 17	+ 29	- 39	- 51	- 26	- 4
α Orionis . . .	- 19	- 14	- 24	- 23	+ 6	- 26	- 35	- 40	- 13
α Canis Majoris . . .	...	-(191)	-(94)	- 23	- 10	- 62	-(94)	-(165)	...
α Canis Minoris . . .	- 49	+ (39)	-(104)	- 83	+ 7	- 67	-(299)	- 1	- 3
β Geminorum . . .	- 39	- 26	- 34	- 33	+ 6	- 56	- 45	- 50	- 6
α Hydræ . . .	- 9	+ 7	- 34	- 33	+ 4	- 28	- 47	- 22	- 9
α Leonis . . .	- 29	- 12	- 44	- 33	- 3	- 63	- 45	- 50	+ 1
β Leonis . . .	- 19	- 4	- 24	- 33	- 4	- 36	- 12	- 17	+ 1
α Virginis . . .	+ 11	+ 1	- 34	- 43	- 19	- 4	+ 7	+ 2	...
α Bootis . . .	- 19	+ 11	+ 6	- 3	+ 11	+ 4	+ 2	- 3	+ 21
α ² Libræ . . .	+ 11	+ 1	- 4	+ 17	+ 15	+ 17	+ 8	+ 3	...
α Coronæ . . .	- 19	- 8	- 4	- 3	+ 10	+ 6	+ 14	+ 9	+ 9
α Serpentis . . .	+ 11	+ 30	+ 16	+ 17	+ 5	+ 25	+ 13	+ 38	+ 15
α Scorpii . . .	+ 11	- 3	- 34	- 47	- 17	+ 12	+ 26	+ 11	...
α Herculis . . .	- 19	+ 10	+ 16	+ 17	+ 0	+ 18	+ 39	+ 34	- 1
α Ophiuchi . . .	+ 11	+ 8	+ 36	+ 27	+ 7	+ 38	+ 36	+ 31	+ 22
α Lyræ . . .	- 9	- 21	+ 6	+ 7	- 8	+ 59	+ 13	+ 8	- 4
γ Aquilæ . . .	- 9	+ 20	+ 26	...	- 5	+ 50	+ 41	+ 36	- 3
α Aquilæ . . .	+ 11	- 2	+ 26	+ 17	- 10	+ 40	+ 18	+ 13	- 8
β Aquilæ . . .	+ 31	+ 33	+ 36	+ 37	+ 6	+ 55	+ 46	+ 41	+ 8
α ² Capricorni . . .	+ 31	+ 27	+ 36	+ 37	+ 2	+ 22	+ 55	+ 51	...
α Cygni . . .	...	- 5	+ 16	+ 17	- 4	...	+ 17	+ 12	+ 13
α Aquarii . . .	+ 41	+ 30	+ 16	+ 27	- 10	+ 19	+ 47	+ 42	+ 10
α Piscis Australis . . .	+ 61	+ 38	+ 16	+ 27	- 17	+ 3	+ 51	+ 46	...
α Pegasi . . .	+ 21	- 12	+ 16	+ 7	- 11	+ 28	+ 6	+ 1	- 8
[v]	+305 -296	+249 -234	+296 -306	+352 -362	+149 -147	+443 -427	+506 -491	+419 -415	+126 -137

The following are the values of m and n , computed from the residuals of Table III. For the purpose of easy comparison, the values derived from the observations are repeated:—

	From the Provisional Catalogues.		From the Observations.	
	m .	n .	m .	n .
Greenwich	—17	+21	— 7	+11
Washington, I. . .	—21—28+(5)	+21+21—(7)	— 9	+ 7
Oxford	—17	+21	—14	+21
Paris	—14	+ 3	—24	+21
Melbourne	—41	+26	—34	+21
Edinburgh	—17	+21	—13	+16
Brussels	—47	+19	—39	+22
Washington, II. . .	—38	+18	—42	+19
Harvard College . .	—10	— 2	— 3	+ 2
Means	—25	+17	—21	+16

It therefore appears:—

(a) That the periodic errors of the provisional places are largely transferred to the observations.

(b) That in general, the coefficients derived from the observations are smaller than those derived from the provisional catalogues, the diminution being quite nearly the amount indicated by theory. But it will be observed that, with the Washington corrections from 1862 to 1865, the periodicity is slightly increased, while in the case of Paris the increase is very decided.

(c) That observations made at different observatories, but depending on the same star places, give substantially the same coefficients, the difference being the effect of errors depending on the declination. Thus in the case of Greenwich and Edinburgh, the declination errors tend to neutralize the errors of single period; while in the case of Oxford, the two causes act together, giving larger coefficients.

(d) That whether the clock errors depend on the places of the Nautical Almanac directly, as in the case of Washington II., or on the same places corrected by observations, as in the case of Brussels and Melbourne, the periodicity is transferred to the observations with about equal diminution.

It will be observed that the residuals for α Canis Majoris and α Canis Minoris (in parenthesis) have been excluded in the derivation of m and n . Where the erroneous places of these stars enter into the clock errors, as in the case of Washington II., they should be included. In this case two errors are introduced. First, an error through ϵ , extending over the whole 24 hours. Thus, when ϵ is negative, all the negative residuals will be too small, and all the positive ones too large. Second, if these residuals are excluded in the formation of ϵ , but are still included in the derivation of m and n , the effect will be to

increase the value of m relatively to that of n , inasmuch as $\sin a$ is at this point nearly maximum, while $\cos a$ is nearly minimum. Including these stars, the coefficients become as follows:—

Nautical Almanac . . .	$m = -50$	$n = +20$
American Ephemeris . . .	$m = -28$	$n = +26$

Of course the same fundamental catalogue may, through erroneous or irregular proper motions, give different coefficients at different epochs. Thus, for Leverrier, 1870, $m = -23$, and $n = +2$, excluding Sirius and Procyon.

As this tendency to negative residuals in the case of Sirius and Procyon appears in nearly all modern catalogues, it occurred to me that we might find here, an explanation of the way in which periodic errors came to be introduced. I accordingly began the inquiry, whether the errors in question may not be due to the irregular proper motions of the stars employed for determining clock errors, and especially of Sirius and Procyon. An examination of Maskelyne's observations indicates an apparent periodicity in a few cases. This subject, however, is in its detail, reserved for a future communication. It is sufficient for our present purpose to limit the inquiry to Sirius and Procyon. In case these stars were persistently used as clock stars, with places largely in excess of their true positions, all resulting Right Ascensions in their vicinity would be increased in proportion to the number and range of the stars employed. There seems, however, to be several objections to this supposition as a complete explanation.

(1.) The residuals given by various catalogues, at different epochs, do not wholly follow the irregular motions of these stars. Taking Sirius alone and assuming its Right Ascension to be known for 1816 (which I assume to be the time when the present system of differential observations was first introduced), the predicted Right Ascension for each successive year would be too small, and between this date and 1843, the change would amount to .30^s. Hence, we should expect a tendency to positive instead of negative residuals between these dates; if Sirius was the sole cause of the disturbances. On the other hand, between 1843 and 1868, the Right Ascension was continually decreasing, hence, if the place given by the first Greenwich Catalogue was carried forward through this interval, the resulting clock errors given by this star were too large. This would of course produce a tendency to the negative residuals which actually exist.

(2.) In the Greenwich system of observations adopted in 1836, and generally followed by all English Observatories, the places of the clock stars have been derived from the observations of the previous year. Hence the periodicity of Sirius and Procyon has since that date been completely allowed for.

(3.) If the irregular motions of these stars were the sole cause of the observed periodic errors of single period, the formula, $r = m \sin a + n \cos a$, would no

longer represent the proper distribution of these errors. As has been remarked, they should be distributed in proportion to their influence on the clock errors. The maximum periodicity should occur at about 7^h and should decrease, slowly at first, and disappear at about 4^h and 10^h . This is what actually happens, as far as the negative residuals are concerned; but it appears from this discussion that the expression, $r = m \sin a + n \cos a$, does, as a matter of fact, represent the proper distribution of the errors of single period over the whole 24 hours. This requires that we shall find at about 18^h , stars giving large positive residuals. As no stars near this hour of Right Ascension appear to have irregular proper motions, the explanation so far fails.

But it appears that the expression, $m \sin a + n \cos a$, is, in a certain sense, the complement of $a \sin \delta + b \cos \delta$. An examination of the several tables will show that when the corrections for errors of single period are applied, there is a constant tendency to negative residuals, but that when the corrections depending on the Declination are applied, the equilibrium is nearly restored. It therefore occurred to me that the supplemental positive residuals required at 18^h may have been introduced by defective or irregular pivots in some of the earlier observations. Inasmuch as all the Maskelyne fundamental stars which have a large south declination (except Sirius) occur between 14^h and 23^h , it is required to find a system of observations, which has been largely adopted as fundamental in differential observations, and in which the coefficients, a and b , are such as will give large positive residuals for low southern stars. As differential observations were first introduced by Pond in 1816, and as his observations have had great weight in the formation of subsequent catalogues, we should naturally expect to find this condition fulfilled in his observations. In order to furnish all the data at present available, in deciding whether the errors in question are in any sense inherent in the observations themselves, or are wholly transferred from the provisional places of the clock stars, I give on the following pages, the residuals, corrected for ϵ , for all the catalogues at hand, between 1750 and 1871. In a few cases no reduction for equinox has been made, on account of the wide range in the values of the residuals. Such cases are indicated by the omission of ϵ and $[v]$. Whenever the first and last dates are given, and the mean epoch is *not* given, it is to be understood that the residuals have been derived from all the observations between those dates, as given in the various annual volumes. Provisional authorities are indicated by (F).

TABLE IV.

	Lacaille, 1750.	Bessel's Brad- ley, 1755.	Maskelyne's Bradley, 1756.	Tobias Mayer, 1756.	Maskelyne, 1766.	Maskelyne, 1770.	Maskelyne, 1784.	Maskelyne, 1790.	Zach. 1800.	Piazzi, 1800.	Lalande, 1800.	D'Alembert, 1800.	D'Alembert (F.), 1800.	Maskelyne, 1802.	Maskelyne, 1803.	Anwers' Cac- ulator, 1805.	Leverrier, 1800.	Bessel, 1815.	Pond's Mask- elyne, 1815.	Pond's Mask- elyne, 1819.	Pond (1816-21) 1819.
α Andromedæ . . .	+350	—	+120	+140	—	+65	+222	+274	+366	+110	—	—	—	+108	+151	—	+	+210	+172	—158	—141
γ Pegasi . . .	+74	+99	+240	+30	+75	+44	+62	+69	—	+68	+70	—	—	—	—	—	+	+73	+12	+7	+63
α Arietis . . .	+149	+73	+90	+320	+85	+68	+32	+36	—	+52	+310	+410	+9	—	—	—	+	—	+22	+42	+20
α Ceti . . .	+154	+20	+350	+30	+75	+85	+12	+13	+134	+8	+8	+480	+9	+92	+108	+	+	+76	+88	+18	+18
α Tauri . . .	+126	+30	+70	+30	+5	+4	+12	+13	+86	+82	+230	+300	+1	+102	+108	+	+	+2	+158	+58	+58
α Aurigæ . . .	+416	+40	+40	+40	+205	+707	+82	+173	+306	+30	+50	+50	+9	+38	+46	+	+	+24	+42	+12	+3
β Orionis . . .	+570	+36	+160	+210	+15	+164	+62	+2	+13	+34	+90	+230	+9	+38	+46	+	+	+24	+42	+12	+3
β Tauri . . .	+836	+145	+120	+90	+25	+54	+62	+2	+13	+34	+90	+230	+9	+38	+46	+	+	+24	+42	+12	+3
α Orionis . . .	+74	+34	+170	+320	+35	+23	+12	+26	+146	+19	+5	+0	+60	—	—	+	+	+52	+52	+25	+68
α Caris Majoris . . .	+205	+84	+90	+160	+75	+187	+22	+26	+126	+72	+20	+170	+9	—	—	+	+	+108	+22	+6	+17
α Caris Minoris . . .	+175	+57	+170	+330	+65	+17	+8	+23	+6	+103	+110	+500	+71	—	—	+	+	+97	+22	+36	+17
β Geminorum . . .	+243	+122	+90	+120	+35	+49	+12	+34	+76	+42	+70	+860	+9	+52	+12	+	+	+102	+28	+70	+55
α Hydree . . .	+749	+140	+180	+340	+135	+159	+8	+47	+124	+11	+260	+120	+39	—	—	+	+	+9	+28	+27	+45
α Leonis . . .	+246	+121	+180	+00	+25	+80	+18	+16	+6	+33	+140	+360	+30	+68	+23	+	+	+11	+30	+27	+27
β Leonis . . .	+174	+101	+140	+170	+115	+83	+18	+22	+34	+34	+110	+610	+29	+118	+53	+	+	+17	+62	+28	+39
α Virginis . . .	+182	+43	+40	+260	+115	+103	+58	+42	+24	+44	+230	+70	+21	+38	+45	+	+	+26	+52	+45	+43
α Bootis . . .	+49	+38	+80	+280	+45	+1	+2	+13	+34	+55	+130	+1280	+31	+32	+51	+	+	+6	+52	+35	+22
α^2 Libræ . . .	+194	+196	+20	+300	+125	+111	+48	+25	+4	+48	+48	+40	+29	+12	+12	+	+	+78	+12	+64	+50
α Coronæ . . .	+98	+68	+150	+600	+265	+28	+18	+90	+236	+124	+90	+150	+21	+68	+31	+	+	—	+57	+39	+39
α Serpentis . . .	+41	+115	+130	+20	+55	+25	+22	+15	+14	+200	+0	+130	+9	+18	+21	+	+	—	+20	+2	+25
α Scorpis . . .	+249	+83	+130	+30	+55	+25	+12	+22	+54	+32	+111	+70	+41	+168	+81	+	+	+76	+78	+36	+113
α Herculis . . .	+453	+36	+130	+20	+55	+25	+12	+22	+54	+32	+111	+70	+41	+168	+81	+	+	+76	+78	+36	+113
α Opitchi . . .	+228	+182	+47	+100	+35	+80	+62	+106	+166	+11	—	+70	+9	+22	+22	+	+	+39	+102	+79	+54
α Lyre . . .	+551	+153	+30	+500	+45	+80	+88	+132	+214	+54	+80	+380	+11	+132	+88	+	+	+19	+102	+79	+54
γ Aquilæ . . .	+130	+143	+210	+210	+45	+28	+32	+16	+16	+2	+150	+90	+11	+32	+3	+	+	—	+8	+26	+2
β Aquilæ . . .	+142	+143	+210	...	+45	+29	+32	+26	+16	+2	+150	+90	+11	+32	+3	+	+	—	+8	+26	+2
α^2 Capricorni . . .	+133	+21	+40	+90	+5	+28	+2	+3	+4	+106	+150	+90	+11	+32	+3	+	+	—	+8	+26	+2
α Cygni . . .	+525	+128	+120	+280	+15	+3	+22	+16	+26	+92	+130	+20	+19	+92	+33	+	+	+33	+28	+53	+42
α Aquarii . . .	+67	+117	+240	+310	+65	+25	+22	+16	+334	+73	+60	+950	+1	+72	+87	+	+	+10	+8	+8	+18
α Piscis Australis . . .	+92	+27	+220	+220	+5	+214	+128	+174	+244	+50	+73	+60	+950	+1	+72	+	+	+37	+88	+73	+228
α Pegasi . . .	+365	+00	+220	—	+105	+73	+8	+49	+124	+1	+180	+70	+1	+92	+21	+	+	+67	+2	+25	+17
[v]	—	—	—	—	+1010	+933	+556	+852	+1444	+851	—	—	—	+952	+527	+	+	+838	+618	+622	+675
	—	—	—	—	+1000	+940	+540	+861	+1446	+840	—	—	—	+948	+523	+	+	+822	+622	+630	+676

TABLE IV.

	Pond, 1820.	Pond, 1823.	Brinkley, 1824.	Pond (1821-26) 1825.	Bessel, 1825.	a Can. Min., 1825.	Struve I., 1825.	Struve II., 1825.	Parametta, 1825.	Pond (1825-28) 1826.	Bessel, 1827.	Pond, 1827.	Struve, 1830.	Argelander, 1830.	Pond I., 1830.	Pond II., 1830.	1816-33.	Atty. Camb., 1830.	Atty (F.), 1830.	Atty (F.), 1835.	Fallows, Cape Good Hope, 1830.	Fallows (F.), Bessel Tab. Reg. 1830.
²																						
Andromedæ	173	145	151	43	40	27	43	17	—	—	19	—	46	45	18	168	—	54	—	—	19	+
γ Pegasi	66	65	31	47	45	67	61	62	570	42	21	—	44	65	18	18	16	26	172	140	19	+
γ Arietis	41	55	11	57	38	34	14	10	140	62	39	—	64	35	28	68	38	34	68	—	21	+
α Ceti	10	15	31	49	19	34	17	7	650	—	14	—	14	15	8	2	56	14	2	40	21	+
α Tauri	95	75	49	53	19	68	19	6	380	68	31	—	66	15	2	62	44	6	102	30	31	+
α Aurigæ	14	5	5	27	27	27	27	27	330	8	31	—	25	25	2	2	4	14	12	30	41	+
β Orionis	74	69	39	37	70	24	47	43	490	68	39	—	66	45	23	42	24	44	32	0	31	+
β Tauri	28	11	9	16	16	30	28	33	190	13	11	—	24	15	8	8	6	14	42	0	11	+
α Orionis	14	15	9	17	27	18	16	31	250	12	11	—	24	15	8	8	6	14	42	0	11	+
α Canis Majoris	68	73	39	73	86	4	3	31	130	88	31	—	106	15	22	132	104	34	8	40	11	+
α Canis Minoris	32	113	21	51	12	4	1	9	130	72	19	—	84	5	22	118	146	4	132	170	41	+
β Geminorum	82	63	41	57	9	..	1	19	450	52	31	—	54	23	8	132	104	4	248	20	1	+
α Hydræ	30	55	101	41	..	..	31	29	80	62	31	—	54	23	8	118	146	4	248	20	1	+
β Leonis	47	45	9	47	63	12	31	1	100	42	11	—	54	23	8	68	56	16	68	40	49	+
α Leonis	42	35	1	37	67	8	9	1	380	42	21	—	54	23	8	68	56	16	68	40	49	+
α Virginis	52	55	19	23	2	46	0	5	180	28	29	—	16	5	2	32	34	14	72	20	31	+
α Bootis	32	5	9	7	25	25	13	13	330	2	1	—	4	15	12	12	24	4	12	10	39	+
α ² Libræ	52	45	9	27	64	50	22	26	..	..	11	—	24	15	12	18	36	4	28	10	11	+
α Coronæ	48	35	9	17	10	21	2	29	..	..	11	—	24	15	12	18	36	4	28	10	39	+
α Serpentis	14	15	19	7	10	21	2	29	..	..	11	—	24	15	12	18	36	4	28	10	39	+
α Herculis	110	115	29	113	39	10	34	36	620	2	1	—	4	45	8	2	4	24	12	0	9	+
α Scorpii	43	15	21	3	27	10	33	28	150	118	19	—	116	45	32	102	114	14	132	50	21	+
α Ophiuchi	36	15	1	17	54	37	44	44	510	8	61	—	14	35	18	22	24	26	2	10	..	+
α Lyre	66	55	41	57	54	33	47	36	490	12	1	—	44	55	8	24	16	6	48	..	71	+
γ Aquilæ	15	15	19	9	7	..	3	3	260	42	1	—	44	55	8	24	16	6	48	..	19	+
β Aquilæ	8	5	19	10	22	..	10	10	260	2	1	—	44	55	8	24	16	6	48	..	19	+
α Capricorni	104	95	49	83	32	..	1	37	10	12	29	—	4	5	2	38	16	66	30	..	29	+
α Cygni	42	45	39	37	32	26	40	41	760	88	19	—	76	45	22	52	34	66	112	30	19	+
α Aquarii	38	15	21	34	15	5	71	5	400	42	19	—	54	75	2	28	26	4	38	..	9	+
α Piscis Australis	219	235	20	164	57	164	34	2	130	68	99	—	6	5	22	162	144	26	22	20	19	+
α Pegasi	20	25	1	37	35	28	22	28	360	32	1	—	34	25	8	28	26	26	28	10	..	+
[a]	773	755	413	643	542	494	370	307	566	361	382	—	390	180	650	600	304	688	340	317	408	+
	774	745	414	637	558	485	354	308	580	349	690	—	405	178	636	592	300	676	340	311	406	+

TABLE IV.

	Johnson, St. Helena, 1830.	Johnson (F.), N. A. 1830.	Ast. Soc. 1830.	Pond, 1829-30-31.	Pond, 1833-34-35.	Henderson, Cape Good Hope, 1833.	Taylor, Madras, 1832.	Taylor (F.), 1832.	San Fernando 1835.	Pond, 1835.	Greenw. 1840.	Greenw. (F.), 1836.	Greenw. 1845.	Gillis, 1840.	Gillis (F.), Radcliff (F.), N. A. 1840.	Radcliff, 1845.	Pulkowa, 1845.	Greenw. 1850.	B. A. C. 1850.	Edinburgh, 1835-36.	Edinburgh, 1837-40.
2	89	55	—	46	17	27	59	45	26	30	75	—	18	—	7	2	61	—	—	28	37
α Andromedæ	72	35	360	76	4	4	15	..	16	16	85	1	2	18	8	82	4	50	—	8	37
γ Pegasi	42	55	70	37	23	23	45	75	12	64	5	1	12	29	57	+	6	13	0	8	32
α Arctis	8	320	14	14	14	17	45	5	23	69	5	+	2	29	107	+	22	17	80	13	8
α Ceti	360	85	160	17	4	17	25	55	71	39	55	29	3	3	2	+	3	17	10	18	19
α Tauri	2	15	360	34	10	27	105	5	22	21	55	41	+	38	5	+	3	17	10	18	19
α Aurigæ	52	35	270	46	46	20	105	15	24	63	85	31	+	8	2	+	15	30	10	18	19
β Orionis	22	65	150	87	20	17	45	38	31	32	15	20	+	53	22	+	15	30	10	18	19
β Tauri	18	35	110	43	25	21	45	3	4	22	25	11	+	53	42	+	15	30	10	18	19
α Orionis	18	23	40	43	25	21	45	3	4	22	25	11	+	53	42	+	15	30	10	18	19
α Canis Majoris	2	135	80	24	22	13	25	35	20	20	45	49	+	112	16	+	21	30	10	18	19
α Canis Minoris	2	115	30	3	60	23	75	145	13	13	5	51	+	34	16	+	21	30	10	18	19
β Gemini	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
α Hydre	42	55	340	54	116	23	15	65	9	183	5	49	+	112	60	+	21	30	10	18	19
α Leonis	2	55	260	23	17	17	105	75	25	183	53	101	+	112	60	+	21	30	10	18	19
β Leonis	2	55	320	4	23	17	105	75	9	82	25	41	+	103	122	+	21	30	10	18	19
β Virginis	12	35	190	4	53	17	55	35	62	153	25	11	+	103	122	+	21	30	10	18	19
α Bootis	18	15	130	29	20	23	55	45	30	29	25	5	+	34	56	+	21	30	10	18	19
α Bootis	48	15	310	73	17	23	55	85	8	13	5	29	+	53	34	+	21	30	10	18	19
α Libræ	48	15	30	97	27	17	45	5	60	12	5	11	+	16	18	+	21	30	10	18	19
α Corone	2	15	440	33	33	33	25	15	52	69	5	41	+	42	15	+	21	30	10	18	19
α Serpentis	2	5	700	73	33	33	25	15	88	39	15	11	+	21	60	+	21	30	10	18	19
α Scorpis	2	125	210	33	24	57	55	105	15	111	15	19	+	36	58	+	21	30	10	18	19
α Herculis	68	15	400	69	4	13	55	25	35	11	25	19	+	35	41	+	21	30	10	18	19
α Ophiuchi	42	35	230	59	10	7	5	15	35	33	15	19	+	19	62	+	21	30	10	18	19
γ Aquilæ	48	25	360	70	56	17	5	15	30	33	15	51	+	31	16	+	21	30	10	18	19
β Aquilæ	48	25	360	70	56	17	5	15	30	33	15	51	+	31	16	+	21	30	10	18	19
α Capricorni	2	85	20	36	34	13	45	25	30	17	5	49	+	44	32	+	21	30	10	18	19
α Cygni	2	65	410	67	32	27	45	15	31	27	45	9	+	11	24	+	21	30	10	18	19
α Aquarii	12	5	130	11	0	13	35	25	61	33	15	79	+	38	58	+	21	30	10	18	19
α Piscis Australis	8	15	80	104	5	17	135	45	37	35	95	89	+	40	15	+	21	30	10	18	19
α Pegasi	338	635	—	668	408	362	625	735	588	614	485	516	330	617	701	716	193	352	—	271	268
[v]	328	650	—	668	476	346	625	720	590	625	495	516	326	604	699	714	205	356	—	284	268

TABLE IV.

	Edinburgh, 1843-47.	Edinburgh, 1849-59.	Cambidge, 1836-41.	Cambidge, 1843-48.	Cambidge, 1850-54.	Cambidge, 1855-59.	Cambidge, 1860.	Cambridge (F.), 1860.	Washington, 1846-52.	Washington (F.), N. A. 1845.	Pulkowa 1845.	Radcliff, 1845.	Safford, 1855.	Cape Good Hope, 1856.	Cape Good Hope (F.), 1860.	Radcliff, 1860.	Greenwich, 1860.	Amer. Eph. I. 1860.	Conn. Des Temps, 1860.	Conn. Des Temps, 1869.
Andromeda . . .	76	15	74	19	17	22	75	63	7	+	19	2	17	33	17	39	+	31	87	+
γ Pegasi . . .	45	5	13	8	19	15	35	5	3	+	4	4	31	57	7	31	+	9	+	3
α Arctis . . .	8	11	16	24	1	12	15	21	17	+	4	82	31	33	3	39	+	9	+	17
α Ceti . . .	10	3	24	12	9	8	15	34	5	+	17	32	30	7	3	11	+	9	+	33
α Tauri . . .	22	22	13	6	3	4	55	61	30	+	26	18	16	207	23	15	+	39	+	33
α Aurigæ . . .	70	14	23	11	1	12	45	95	60	+	1	52	43	17	7	29	+	41	+	57
β Orionis . . .	2	50	35	26	1	13	15	25	32	+	3	22	3	43	23	11	+	101	+	87
β Tauri . . .	18	18	35	4	9	10	35	37	27	+	7	42	3	17	23	23	+	9	+	17
α Canis Majoris . . .	24	8	3	26	7	18	15	25	32	+	20	48	31	3	17	29	+	11	+	12
β Canis Minoris . . .	23	18	3	8	3	6	35	27	13	+	14	2	30	17	17	69	+	11	+	12
β Geminorum . . .	24	12	29	14	33	20	55	47	63	+	19	19	14	107	23	33	+	261	+	267
α Leonis . . .	38	22	33	33	43	33	55	22	63	+	2	98	12	27	17	29	+	49	+	113
α Virginis . . .	3	17	26	7	29	11	5	45	103	+	16	58	0	108	37	21	+	21	+	12
β Virginis . . .	8	3	34	23	31	20	15	15	43	+	10	48	7	27	37	39	+	1	+	47
α Bootis . . .	12	1	10	2	31	32	25	3	21	+	28	58	4	53	27	17	+	9	+	8
α ² Libræ . . .	28	28	1	29	33	4	35	8	6	+	16	18	18	13	13	31	+	19	+	13
α Coronæ . . .	18	26	16	11	31	28	5	36	28	+	36	88	2	63	9	9	+	9	+	8
α Serpentis . . .	28	6	4	1	19	4	11	3	3	+	8	42	8	3	27	9	+	9	+	47
α Herculis . . .	28	28	28	23	29	14	35	11	73	+	23	28	2	47	13	1	+	39	+	33
α Scorpil . . .	4	26	32	11	12	28	105	34	37	+	2	28	18	23	13	9	+	9	+	27
α Ophiuchi . . .	30	31	31	9	3	48	115	28	47	+	31	52	2	63	37	81	+	9	+	43
α Lyre . . .	35	39	31	13	15	0	15	9	54	+	16	32	4	13	17	61	+	21	+	73
γ Aquilæ . . .	35	39	31	13	15	0	15	36	87	+	30	42	4	13	17	71	+	29	+	3
α Aquilæ . . .	62	46	0	16	7	3	85	14	49	+	16	42	8	3	3	31	+	29	+	3
β Aquilæ . . .	35	18	21	19	3	0	85	40	7	+	13	62	3	23	33	39	+	39	+	13
α ² Capricorni . . .	18	15	4	21	9	11	25	48	13	+	45	2	2	7	23	39	+	39	+	73
α Cygni . . .	12	30	28	39	9	17	5	40	44	+	18	26	24	153	101	101	+	9	+	53
α Aquarii . . .	6	24	30	39	9	0	40	27	23	+	0	8	8	77	23	21	+	33	+	63
α Piscis Australis . . .	36	1	2	1	23	7	15	50	85	+	15	62	4	17	53	21	+	39	+	123
α Pegasi . . .	385	275	216	187	211	215	405	408	396	+	175	716	181	451	298	496	+	458	+	462
[α]	—370	—285	—230	—198	—207	—225	—460	—393	—408	+	—178	—714	—191	—452	—301	—484	+	—460	+	—478

TABLE IV.

	American Ephem. II. Gould, 1860.	American Ephem. II. Gould, 1880.	Wolfsers' Tab. Reg. 1860.	Wolfsers' Tab. Reg. 1880.	Leverrier, 1870.	Leverrier, 1900.	Paris (Observat'ns.) 1867.	Washington (Observat'ns.) 1871.	Greenwich (Observat'ns.) 1871.
ϵ . . .	+ 15	+ 9	- 17	- 18	+ 41	+ 58	+ 45	+ 3	+ 41
α Andromedæ . .	+ 10	+ 21	+ 37	+ 61	+ 15	+ 54	+ 0	- 27	+ 19
γ Pegasi . . .	+ 1	- 9	- 32	- 40	+ 11	+ 19	+ 16	- 27	+ 29
α Arietis . . .	+ 1	- 4	- 3	+ 0	- 14	- 8	+ 28	+ 2	- 11
α Ceti . . .	- 4	+ 1	+ 19	+ 25	+ 35	+ 47	+ 15	+ 27	+ 29
α Tauri . . .	- 20	18	8	- 14	- 58	86	- 32	+ 15	- 21
α Aurigæ . . .	- 37	- 39	- 50	- 79	- 138	- 231	+ 58	+ 3	+ 19
β Orionis . . .	+ 3	+ 6	- 10	- 26	+ 2	- 2	(179)	+ 68	- 21
β Tauri . . .	- 1	+ 9	+ 0	- 7	- 14	- 55	67	- 22	- 21
α Orionis . . .	- 25	- 25	- 36	- 57	- 21	- 29	- 44	+ 31	- 1
α Canis Majoris .	(61)	(38)	(29)	(11)	(325)	(166)	18	93	81
α Canis Minoris .	(23)	(160)	(9)	(133)	(75)	(38)	57	15	11
β Geminorum . .	- 32	- 33	- 14	- 14	- 28	- 46	19	+ 26	+ 1
α Hydræ . . .	- 30	- 28	- 11	- 7	+ 15	+ 31	+ 2	+ 44	- 11
α Leonis . . .	- 44	- 58	+ 2	+ 13	- 9	- 5	18	- 46	- 21
β Leonis . . .	- 21	- 23	- 7	- 7	+ 1	+ 12	+ 26	- 24	- 11
α Virginis . . .	- 29	- 48	- 1	+ 0	- 7	- 19	- 33	- 83	- 1
α Bootis . . .	+ 5	+ 15	+ 20	- 38	- 14	- 82	- 3	- 43	+ 29
α^2 Libræ . . .	- 7	+ 0	+ 12	+ 15	+ 6	- 9	- 52	- 24	- 1
α Coronæ . . .	+ 5	+ 1	- 8	- 5	- 2	- 7	+ 18	- 10	- 21
α Serpentis . . .	+ 17	+ 27	+ 4	+ 7	+ 38	51	- 5	- 54	+ 19
α Scorpii . . .	- 21	- 38	+ 18	+ 18	- 3	- 14	- 11	- 14	- 71
α Herculis . . .	+ 15	+ 14	- 17	- 27	+ 11	+ 0	+ 37	+ 14	- 21
α Ophiuchi . . .	+ 32	+ 38	+ 23	+ 32	+ 18	+ 34	+ 5	+ 17	+ 9
α Lyræ . . .	+ 11	- 8	+ 5	+ 5	- 25	- 51	(265)	+ 60	+ 19
γ Aquilæ . . .	+ 20	+ 19	+ 2	- 2	+ 24	+ 22	- 35	- 4	+ 9
α Aquilæ . . .	+ 30	+ 30	- 10	- 22	- 4	- 21	- 24	+ 4	- 29
β Aquilæ . . .	+ 27	+ 41	- 4	- 6	+ 40	+ 45	- 6	+ 5	- 11
α^2 Capricorni . .	+ 30	+ 47	+ 6	+ 10	+ 34	+ 45	+ 3	- 32	+ 19
α Cygni . . .	+ 13	+ 19	+ 30	+ 52	- 1	- 3	- 88	+ 32	+ 69
α Aquarii . . .	+ 15	+ 15	- 1	+ 1	+ 38	+ 55	+ 35	- 7	- 11
α Piscis Australis	+ 19	+ 9	+ 37	+ 24	+ 36	+ 25	...	+ 75	+ 59
α Pegasi . . .	+ 17	+ 13	+ 3	+ 4	- 8	- 4	1	+ 0	- 21
[v]	+271 -271	+333 -323	+218 -212	+305 -313	+331 -339	+560 -552	+375 -381	+469 -476	+357 -369

From an examination of the residuals of the preceding tables, the following conclusions are drawn:—

I. That the magnitude of the accidental errors, in all observations prior to Maskelyne (in their present state of reduction), prevents any safe inference with respect to periodic errors of single period. In general, a certain degree of accuracy must be reached, before it is possible to distinguish with certainty between accidental and periodic errors; and, as I shall presently show, wherever there is an accumulation of accidental errors, periodic errors will be developed in any system of observations, in which there is an irregular distribution of the clock stars in Right Ascension and Declination.

II. That in absolute determinations of Right Ascension, there is no positive evidence of the existence of these errors. An examination of Maskelyne's separate observations will show that the slight periodicity in his later catalogues is apparent rather than real. When we come to more modern observations, we have several instances in which the evidence on this point is quite decisive. Airy's Cambridge observations were nearly absolute determinations. For his clock errors, he used stars in the same parallel; and notwithstanding the decisive evidence of periodicity in his provisional places, it is nearly eliminated

from his observations. The Washington observations for 1845 were absolute determinations. Here the positive and negative errors are pretty evenly distributed, but immediately upon the adoption of the differential system, with the Nautical Almanac places as fundamental, the periodicity becomes strikingly apparent. Johnson's St. Helena Catalogue contains far less evidence of periodicity than we should expect, because he applied to his observations a system of corrections by which the errors of single period were partially eliminated. In Brinkley, Struve, and Argelander, and at Pulkowa, the errors in question are very small, if they exist at all.

The three cases which seem to form an exception to this general statement, are, Bessel 1815, Bessel 1825, and Auwers' Cacciatore 1805. With respect to Bessel's observations, it is to be remarked that they depend entirely upon the places of α Aquilæ and α Canis Minoris, the latter having an acknowledged irregular proper motion. In the catalogue for 1815, the place of α Canis Minoris was assumed .10^s too small, and if the Right Ascensions in this region were made entirely dependent on the position of this star, the error should be distributed, not over the whole arc, but over that part only in which the star was used as a standard. In the catalogue for 1825, which is a combination by weights of the results from each star, the periodicity is more marked than in either system taken separately. In the catalogue for 1827, communicated to Pond, errors of single period can hardly be said with certainty to exist. In Auwers' Cacciatore, the periodicity is more marked, but as will be seen, there is apparently an accumulation of accidental positive errors at about 15^h, and we have here the only instance (except Bessel), in which the coefficient of $\sin \alpha$ has a large positive value. This catalogue does not seem to depend in any way upon Leverrier's positions, with which it is compared, but it is rather curious that the coefficients, m and n , are nearly the same for the two catalogues.

III. That the introduction of an excess of positive residuals between 13^h and 23^h, is due to the inequality of the pivots of the new instrument with which Pond began observations for Right Ascension in 1816. It seems to me that the evidence on this point is decisive. These pivots were used till 1825, when steel pivots were inserted, from which it is to be inferred that the first ones were not made of this material. The new pivots not proving satisfactory, they were re-ground in 1832. I give here, the coefficients a and b for the various catalogues formed by Pond, and I add also, the values derived from the observations just preceding the last correction of the pivots and those immediately following. It is unfortunate for our purpose that the annual results do not appear in the volumes preceding 1829.

EPOCH.	a .	b .
1819 (1816-21)	— .136 ^s	+ .021 ^s
1820 (1816)	— .142	+ .021
1823 (1821-23)	— .135	+ .020
1825 (1821-26)	— .122	+ .018
1826 (1825-28)	— .092	+ .015
1830 (1816-33)	— .087	+ .022
1829-30-31	+ .099	— .015
1833-34-35	— .059	+ .009

It is obvious that we have here an explanation of the positive residuals which appear in all subsequent catalogues in the region of 18^h , this point being nearly the mean of the Right Ascensions of stars having large south Declinations. As will be seen, these positive residuals appear in all catalogues depending directly on Pond's observations, and notably in those found in the earlier volumes of the Nautical Almanac. Wherever these catalogues were made the basis of observations with other instruments, these errors were transferred; a little differently distributed but not eliminated.

Pond seems to have assumed that his first pivots became worn unequally. This proves not to have been the case. On the other hand, the steel pivots seem to have undergone a decided change of form, giving nearly opposite results in 1825 and 1832. The change probably took place after 1828, and it is just here that the confusion becomes inextricable, without a re-reduction of Pond's observations.

We must not assume, however, that the values of a and b for the new pivots are entirely due to the pivots themselves, for by the method of observation, the errors of the old pivots were largely transferred to the new. Hence, the later values of a and b are to be considered as only approximately correct; i. e., they are not the values which would have been found if the observations *e.g.* between 1832 and 1835 had been absolute determinations. It is to be noted also, that the change in the values of a and b , indicates that the irregularity is due to an actual change of form in the pivots rather than to flexure or to weakness of the axis.

This tendency to positive residuals for low southern stars by no means escaped the attention of so illustrious an astronomer and so careful an observer as Pond; but after a thorough investigation of the differences between his observations and those of Bessel and Brinkley, he does not seem to have reached any definite conclusion. Nevertheless, α Piscis Australis was finally dropped from his list of time stars, probably on this account. The following remarks on this subject I quote from the Greenwich observations for 1833.

"With all these precautions, we do not find, by comparing the present observations with these of Bradley, made eighty years ago under the same roof, and computed by the same table of refractions, that we can obtain by interpolation, any intermediate Catalogue that shall agree with the observations within the probable limits of error. *This inclines me to my former opinion, that the proper motions of the stars are not uniform, and that at present our knowledge of them is in a very imperfect state. It has always appeared to me extremely improbable that the proper motions of the stars should be uniform.*" "And, again, we can hardly obtain a better test of our power of predicting the future positions of the stars, than by trying by the same formula how accurately we can interpolate for the past. In a variety of papers which I have submitted to the Royal Society, I have endeavoured to shew that with us the latter experiment *entirely fails.*"

If it is admitted that periodic errors of single period have their origin here, we might expect that when the corrections depending on the Declination are applied, the periodicity should disappear from Pond's observations. But just here is introduced an opposite error through ϵ ; that is, the value of ϵ is, on account of these positive residuals, less than it would have been with perfect pivots, the equinox remaining constant. Excluding 8 stars having large south Declinations, the value of ϵ is, in general, about .04^s numerically greater than the

value derived from the whole system. Hence we should expect a general tendency to positive residuals between 0^h and 12^h , when the corrections depending on the pivots are applied. As a matter of fact, the resulting residuals for this interval, are almost precisely represented by the expression, $r \sin a + r \cos a$. And this relation should exist as long as the observations made with pivots of different figure remain uncombined. But this combination was made by Pond, and it is on this account that he was unable to satisfy even his own earlier observations. Hence for all observations previous to 1828, the accumulation of positive residuals between 0^h and 12^h , resulting from corrections through a and b , must be distributed over this interval only, by the formula $r \sin a + r \cos a$, but after that date, the errors become by combination so intermingled, that we must distribute them over the whole arc of Right Ascension. In Table V., columns 1, 2, 3, 4, and 5, will be found the residuals previously given, corrected by the values of a and b , given above. In column 6 will be found the corrected residuals for Pond's General Catalogue (of 1112 stars). In the last column will be found the mean of columns 1 to 5, corrected for errors of single period. The following are the derived periodic equations.

$$1829-31 \quad . \quad . \quad . \quad . \quad . \quad r = -.023s \sin a - .011s \cos a.$$

$$1833-35 \quad . \quad . \quad . \quad . \quad . \quad r = -.024 \sin a + .017 \cos a.$$

TABLE V.

POND . .	1. 1819 } 1820 } 1821 } Mean.	2. 1821-26.	3. 1825-28.	4. 1829-31.	5. 1833-35.	6. 1816-33.	7. Mean Corr. 1-5.
α Andromedæ . .	- 18	- 6	- 12	+ 42	- 21	+ 6	+ 5
γ Pegasi	- 31	- 43	- 54	- 47	- 17	- 55	- 24
α Arietis	+ 19	+ 23	+ 19	- 38	+ 27	+ 17	+ 0
α Ceti	+ 63	+ 42	+ 59	- 8	- 2	+ 27	- 1
α Tauri	+ 23	+ 30	+ 20	- 48	- 2	- 3	- 6
α Aurigæ	+ 75	+ 78	+ 63	- 62	- 10	+ 72	- 14
β Orionis	+ 27	+ 27	+ 39	- 57	+ 2	- 11	- 6
β Tauri	+ 28	+ 26	+ 19	- 78	- 6	+ 17	- 14
α Orionis	- 13	- 19	- 15	+ 45	- 34	- 17	+ 20
α Canis Majoris .	+ 8	+ 22	+ 48	+ 18	- 4	+(59)	+ 22
α Canis Minoris .	- 62	- 63	- 78	+ 8	- 63	-(159)	- 14
β Geminorum . .	- 22	- 14	- 21	- 42	- 96	- 36	- 34
α Hydræ	- 83	- 92	- 90	- 25	- 37	- 99	- 42
β Leonis	- 33	- 37	- 37	- 11	- 19	- 48	- 17
α Leonis	- 21	- 21	- 31	- 17	- 46	- 24	- 33
α Virginis	+ 4	- 17	- 4	+ 62	+ 0	- 4	+ 13
α Bootis	+ 10	+ 17	+ 15	+ 53	+ 28	+ 33	+ 25
α^2 Libræ	- 104	- 76	- 60	- 57	+ 3	- 80	- 53
α Coronæ	+ 4	+ 23	+ 17	+ 46	- 14	+ 24	+ 5
α Serpentis . . .	- 23	- 10	- 6	+ 36	+ 22	- 8	+ 4
α Scorpii	+ 34	+ 43	+ 65	- 17	+ 20	+ 56	+ 3
α Herculis	- 13	+ 16	+ 16	+ 59	+ 10	+ 25	+ 10
α Ophiuchi . . .	- 19	- 8	- 7	+ 22	+ 14	+ 1	- 7
α Lyræ	+ 10	+ 4	+ 3	+ 10	- 3	+ 19	- 11
γ Aquilæ	- 8	- 3	+ 10	+ 53	+ 19	+ 8	+ 9
α Aquilæ	- 3	- 7	- 3	+ 23	+ 34	- 25	+ 3
β Aquilæ	- 4	- 23	- 18	+ 41	+ 11	- 29	- 3
α^3 Capricorni . .	+ 43	+ 37	+ 52	- 29	+ 10	- 8	- 6
α Cygni	+ 39	+ 35	+ 11	- 22	+ 102	+ 20	+ 23
α Aquarii	- 1	- 7	- 9	+ 38	- 10	- 46	- 3
α Piscis Australis	+ 140	+ 124	+ 8	- 41	+ 29	+ 81	+ 17
α Pegasi	- 2	- 23	- 24	+ 3	+ 23	- 26	- 3
[v]	+527 -460	+547 -462	+464 -469	+559 -599	+354 -384	+406 -518	+159 -291

The remarkable agreement of the residuals in columns 1, 2, and 3, shows conclusively that the observations by Pond were most carefully made; but his pivots have transmitted as a legacy to all subsequent observations, a periodicity which renders their value quite doubtful.

We have here also a partial explanation of the reason why the negative residuals do not follow the irregular motion of Sirius. In the interval between 1816 and 1835, the Right Ascension of Sirius increased about .15^s; but this increase is neutralized by the error depending on the Declination. On the other hand, both causes act together between 1843 and 1868; and it is during this interval that the periodicity of all observations depending on Pond is the most marked. It should also be remarked, that Pond's provisional catalogue, brought forward from Maskelyne, contains slight errors of single period.

IV. That the position of the zero point of the errors depending on the Declination is entirely due to the distribution of the fundamental stars; and that the reason why it remains unchanged, is because these stars retain the same relative positions. The mean Declination of the stars under consideration is about +9°. Had the stars having large south Declinations, been all situated in the first quadrant, the zero points would have been differently located.

V. That the periodic errors of single period have been transmitted to subsequent observations in proportion to their dependence on Pond's catalogues of 720 and 1112 stars, and that the Nautical Almanac, has been largely instrumental in the perpetuation of these errors. The errors of single period found in the Greenwich observations under Airy, are to be ascribed to similar errors in the provisional catalogue adopted in 1836. It would have been fortunate if the first Cambridge Catalogue had been adopted instead. Airy's Cambridge system was continued at that observatory till 1860; and as will be seen by simple inspection of the various sets of residuals, the errors are very small and are mostly due to the Cambridge pivots. But in 1860 there was a return to the Nautical Almanac positions of the clock stars, and immediately the periodicity becomes apparent. The Edinburgh observations for 1835-36 depend on Bessel's *Tabulae Regiomontanæ*; those for 1837-41, on the mean of the Greenwich, Cambridge, and Edinburgh observations for each preceding year; while those subsequent to 1841, depend on the Greenwich clock stars, the places being communicated each year. In the first case, the errors follow those of the *Tabulae Regiomontanæ* quite closely; in the second, the errors of single period are partially eliminated through the values of a and b , peculiar to each instrument; while in the last case, the errors of the Greenwich system are largely reproduced. The errors depending on the Declination are not as apparent previous to 1860, as since that date.

VI. That the variations in the relative values of m and n are due to two causes: viz, —

(a). To the configuration of the clock stars.

(b). To the declination errors peculiar to each instrument.

Under the first head, the most marked case is that of Oxford. The value of n is persistently larger than for other observatories. I apprehend the reason for this is to be found in the fact that in the earlier observations and especially in those made in 1841-2 but few of Maskelyne's clock stars between 17^h and 24^h were used; α Lyræ, α Aquilæ, β Aquilæ, α^2 Capricorni, α Cygni, and α Piscis Australis being omitted. Thus the weight of the errors of the provisional

catalogue fell between the first and the third quadrants. Had Mr. Johnson used the Greenwich clock stars for the same year, he would not have detected the inequality mentioned in the volume for 1841. We find here also an explanation of the difference often found between day and night observations. In January and July the residuals reach their maximum value, but with opposite signs. During these months, therefore, the difference between day and night observations may amount to nearly .10°. On the other hand, in May and November, no appreciable difference will be observed, the observations for these months being near the zero points. It may be found also that the large difference in the values of α and β from the Washington observations of 1866 and 1867, as determined by Professor Newcomb, may be due to the difference in the relative number of observations made in corresponding months of different years.

Under the second head, the most marked cases in more modern observations are Paris, Edinburgh, Washington II., and Harvard College, though in the last case, the coefficients, depending on an average of 6 observations for each star, must be considered as only approximately correct. As has been already remarked, the errors of single period from this cause are in some cases diminished; in others augmented.

To conclude briefly:—

I. The periodic errors of single period existing in observed Right Ascensions, are in no sense inherent in the observations themselves, but are entirely transferred from the provisional places of the clock stars on which they depend.

II. The accumulation of positive residuals in the region of 18^h, is due to the unequal pivots of the Greenwich Transit, erected in 1816.

III. The accumulation of negative residuals in the region of 6^h is due, partly to the general *drift* in the direction of the motion of Sirius and Procyon, and partly to errors developed indirectly from the combination of observations made with unequal or irregular pivots.

IV. The errors thus accumulated are distributed over the whole arc of Right Ascension by means of the formulæ:—

$$m \sin \alpha + n \cos \alpha.$$

$$m' \sin 2\alpha + n' \cos 2\alpha.$$

If the results which I have reached, are accepted as true, it is evident that the speedy return to absolute determinations of Right Ascension is a matter of vital consequence. I venture to suggest that the time has come when astronomers should, by concurrent action, determine which stars shall be regarded as fundamental. If the true elements of *e.g.* 100 stars, properly distributed in Declination, could be decided by recognized authority, and then if all differential observations could be made to depend on these stars only, it would be possible to reach a degree of accuracy unattainable under the present system. For the future, we ought not to be compelled to depend on theory in order to harmonize observations. Theory may be useful in making available, data already accumulated, but observation must be the last resort.